ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Vol. XLVI. No. 18.

TABLE OF CONTENTS:

ENGINEERING NEWS OF THE WEEK.321, 329, 333, 334
Bank Revetment on the Lower Mississippi River (illustrated) 322
Melan Arch Park Bridges at Washington, D. C. (with two-page plate)..... 323
Train Resistance Formulas (illustrated)..... 325
A Statement by Mr. M. W. Kingsley, M. Am. Soc. C. E., Late Superintendnt of the Cleveland Water-Works..... 327
The Nash Gas Engine (illustrated)..... 327
The Trials and Opportunities of a Contracting Engineer..... 328
Book Reviews..... 329
Notes from the Engineering Schools..... 333
The Wager Exposure Scale for Timing the Exposure of Photographic Negatives (illustrated)... 333
A New Steam Vacuum Pump with Positive Valve Motion (illustrated) 334
The Rotary Kiln Process of Cement Manufacture (illustrated)..... 334
EDITORIAL NOTES 330
The "Free Water" Idea Again—Bacteria and Other Natural History Specimens in the Minneapolis Water Supply—Popular Ignorance Concerning Methods by Which Diseases are Spread—A Court Decision Sustaining Property Rights in Trade Names.
EDITORIAL:
Terminal Problems of Interurban Electric Railways. 330
LETTERS TO THE EDITOR.....331, 332
Diagram for Determining Minimum Alternate Spacing of Rivets for Three Diameters, Center to Center (illustrated)—The Relative Impact of Wheels on Broken and Square Joints in Railway Track—Rational and Empirical Features in Formulæ for Flow in Pipes—Notes and Queries.

THE ASPEN TUNNEL, on the Union Pacific Railway in Wyoming, was opened to traffic on Oct. 16. This tunnel is 5,900 ft. long and pierces the Aspen range, one of the Eastern foothills of the Wasatch Mountains. Its construction has been attended with great difficulties owing to the presence of a large volume of water met at different points in its length, gas and crumbling shale. In some places the material swelled like a sponge, crushing all timbering and necessitating the use of iron and steel to brace the heaviest timbers obtainable. Work was commenced on the tunnel nearly ten years ago; but its completion, together with the Bear River-Leroy cut-off, practically shortens the length of the Union Pacific Railway, between Omaha and Ogden, 34 miles. The total cost of the tunnel and cut-off was about $3,000,000.

TRACK ELEVATION IN CHICAGO is to be extended by the elevation of about four miles of line, with 25.80 miles of track. This will include the Chicago, Milwaukee & St. Paul Ry. from 40th to 51st Ave., and the Chicago & Western Indiana Ry. from Chicago and 46th Aves. to Milwaukee Ave. and Irving Park Boulevard. There will be 27 subways, 13 under the C., M. & St. P. Ry., 8 under the C. & W. I. Ry., and 6 under both lines. The elevation of tracks at Grand Crossing is also again being talked of, where the two lines will be raised above the street and one line will be further raised to cross the other. The courts have decided that the city in ordering the elevation of tracks is exercising its police authority in the interest of public safety, and not for its own benefit in any way; consequently, the city is not liable for damages to property consequent upon the elevation of the tracks. This decision, it is believed, will remove many difficulties from the large amount of work yet to be done.

WORK ON THE SEOUL-FUSAN RY., in Corea, was commenced on Aug. 20 last, says U. S. Minister Horace N. Allen, of Seoul. This line will connect Seoul with the southeast part of Fusan and will be 280 miles long; it passes through the rich agricultural country of Southern Corea. A Japanese company holds the concession, and the managing director is Mr. K. Takanouchi, Seoul, and Mr. Adachi, of Chemulpo, Corea, is another leading agent. The directors say that some of the material will be purchased in the United States. The road will be standard gage, and there will be considerable bridge work on the line. It will enter Seoul over the 10-span steel bridge of the Seoul-Chemulpo Railway, built by Americans, and will be operated with this railway. Another railway is being surveyed, to connect Seoul and Weichu or Weiju, to the northwest. This is to be built by French engineers using French materials; and it will tap the coal and gold mining regions of Corea, and may connect with the Russian roads in Manchuria. The director of this latter road is Mr. G. Lefevre, Seoul, Corea.

A RAILWAY EMBANKMENT through a swamp near Cedar Lake, Ind., on the Chicago, Indianapolis & Louisville Ry., has been completed after considerable difficulty, and the place has been spoken of as a "bottomless hole" in the daily papers. The swamp or marsh is just north of Cedar Lake, and is about 850 ft. diameter. In the original construction of the line a pile trestle was built, the piles being spliced to reach the required depth, and in some places four 25-ft. piles were spliced and driven. While traffic was operated on the trestle there was constant trouble due to the structure settling out of line, and this year it was decided to attempt to fill in the trestle, particulars of which work have been furnished us by Mr. W. A. Wallace, Assistant Engineer. South of the trestle is a large cut in clayey material, which was used for filling. After a short time the settling of the material threw the bridge so badly out of line that it was necessary to build a track around the marsh in order to operate trains. A substantial roadbed has now been made, however, by filling in clay and stone; the only cribbing done was that required to keep the track in condition for running the construction trains over it.

CONCRETE RAILWAY BRIDGES are becoming somewhat numerous. In an extensive change of grade at and near Northville, Mich., the Pere Marquette Ry. has built two concrete bridges, each having two semicircular arches of 22 ft. span. The work was done under the direction of Mr. G. H. Kimball, Chief Engineer.

THE AUSTRALIAN-LONDON MAIL was lately delivered via San Francisco, Chicago, Buffalo and New York, in 31 days 5 hours, as compared with 35 days, the average time, via the Suez Canal. This mail left Sydney on Aug. 13 at 10 a. m.; arrived at San Francisco on Sept. 2, and was delayed by quarantine until Sept. 3; it reached Chicago on Sept. 6, at 9.08 a. m.; reached Buffalo on Sept. 6 at 10.10 p. m., and arrived at New York on Sept. 7 at 9.57 a. m.; it was transferred to the "Campania," sailing the same day, and arrived at Queenstown Sept. 13, at 3.31 p. m., and reachd London on Sept. 14, at 7 a. m. The full detail of this trip is given in No. 11 of the "Four-Track Series," issued by the New York Central R. R. Passenger Department.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was the wreck of a passenger train on the Chicago, Burlington & Kansas City Ry., near Exline, Ia., on Oct. 24. Thirty-six passengers were injured, nearly a dozen fatally. A soft place in the roadbed is given as the cause of the wreck.

A SUSPENSION FOOT BRIDGE over the Missouri River at Great Falls, Montana, fell on Sept. 27. By great good fortune the accident occurred about 2.30 a. m., at a time when no one was crossing the structure. The bridge was about 1,100 ft. long, with two spans. The footway was 8 ft. in width. It was built about ten years ago by the Boston & Montana Consolidated Copper and Silver Mining Co., for the use of workmen in its smelter who lived on the opposite side of the river. The fall of the bridge was caused by the giving way of one of the main cables at a point where it was embedded in the concrete anchorage. Newspaper reports indicate that the cable was only held by the adhesion of the concrete. The Great Falls "Daily Tribune" of Sept. 28, said:

> While the statement is made that the cable broke, the ends of the strands which were jerked out of the abutment indicate that they are the end of the cable. There is no indication that any one of them has been broken recently or broken at all. Some have their points sharpened, just as the ending of a cable, and show plainly the portion in the stone and the part in the mud.
>
> The same paper states that the bridge would swing from side to side, and that on the afternoon previous to the accident a party of children played for an hour on the center of the span, swinging it as far as they could.

THE BROWN SEGMENTAL WIRE-TUBE 10-IN. GUN burst at the Sandy Hook proving grounds on Oct. 28, blowing out the breech-block and about 8 ins. of the cast-steel trunnion jacket weighing over 2,000 lbs. This gun was built at Reading, Pa., under an allotment of $33,000 made by the Board of Ordnance and Fortifications, and was inspected on Jan. 9, 1900, and shipped to Sandy Hook. Owing to delays in obtaining suitable powder it was not tested until Feb. 21, 1901; and the first shot, with a pressure of 10,000 lbs., developed a crack in the thin casing over the wire-winding. Later, additional rounds were fired with pressures ranging from 15,700 to 26,900 lbs.; but it was evident that the required velocity could not be obtained with the powder used, and the gun was sent back to Reading to have the chamber capacity increased; it had just been returned for further test. On the ninth test on Oct. 28, 150 lbs. of nitro-cotton was used with a 575-lb. projectile, and the indicator showed a muzzle velocity of 2,230 ft. per second. After allowing the gun to cool for an hour, a charge of 175 lbs. of this powder was placed behind the same projectile, and the destruction of the breech followed. The inventors claim that their patents cover the barrel only—which was uninjured; and that the failure was due to a defect in the trunnion casting, which can be remedied. In spite of the accident the indicator showed a velocity of 2,364 ft. on the second trial. The gun is to be repaired.

A PROJECTILE TEST is to be made at Indian Head at an early date to ascertain why 13-in. shells have lately burst in the guns on the battleships "Kearsarge" and "Alabama." The shells used were armor-piercing and semi-armor-piercing projectiles, made by the Bethlehem Steel Works, J. J. Johnson & Co., Carpenter Steel Works, and the Taylor Iron & Steel Co. During the Spanish-American war complaint was made that the fuses were not sensitive enough, and shells failed to explode; the plunger which is thrown against the fulminate of mercury by the forward movement of the projectile not acting readily. A change was made in these fuses since the war, and it is now feared that the other extreme has been reached, and the exploding charge is fired before the shell has time to reach the muzzle of the gun. This scarring of the heavy guns is a serious matter, as it generally means the replacement of a very costly weapon.

BIDS FOR 15-PDR. RAPID-FIRE GUNS were opened at Washington on Oct. 25. The bids covered 22 guns mounted on barbette pedestal mounts for coast defense purposes. The lowest bid was that of the Bethlehem Steel Co., or $2,545 each for guns complete, with shields, sights and ammunition for testing. The Driggs-Seabury Gun & Ammunition Co., of Derby, Conn., bid $3,450 each; and the American Ordnance Co., bid $4,100 for each gun complete, or $3,200 omitting shields, sights and testing ammunition.

A DETONATOR FOR DYNAMITE has been invented by M. Aubert, of St. Etienne, France, and is thus described by U. S. Consul H. S. Brunot, of that place: It is intended for use in coal mines where gas is present in dangerous volume, and it is operated without the use of electricity. A copper tube receives the end of the fuse for several inches; and at the other end of this tube is a percussion cap similar to those used in toy pistols. This cap lies against the side of the tube, which is there pierced by a small hole, and the fuse end is only .07-in. from the cap. The end of the tube containing the cap is inserted into another copper cylinder containing the firing mechanism. To operate the apparatus the outer tube is held in the hand and a smart blow on a button explodes the cap; the gas from the burning fuse fills the cylinder, but is prevented from escaping outside by the metallic gauze which covers all openings in it. These tubes are loaded outside the mine, so that no stray percussion caps may be brought within; and the copper tubes can be recharged. This device has been used for some months in one of the dangerous mines, and is reported upon as efficient, economical and safe.

THE STEAM ENGINEERING CORPS of the U. S. Navy, says Rear-Admiral Melville, in his last report, is being steadily reduced in the number of its trained and expert steam engineers; and "the outlook for securing a trained engineering force for future needs can hardly be regarded as satisfactory." While some critics suggest a return to the old separate engineer corps, he does not regard the time as opportune for the enactment of such legislation. But Admiral Melville recommends a more liberal and different interpretation of the personnel law, so as to secure more of the advantages contemplated by its originators. Over 100 warrant officers have been appointed and detailed for engine-room duty. But these men come largely from the enlisted men, and have little or no experience in handling large bodies of men, and are not fitted by previous training or experience to take charge of an important department of the ship. If they are competent, why are not the boatswains and gunners as competent to carry on routine deck duty? It required 15 years to develop a satisfactory course of instruction in steam engineering at Annapolis; and it will require time to develop the present system. But to meet present conditions Admiral Melville strongly advises as follows: That a large contingent of junior officers be sent to the various navy yards to secure engineering instruction and experience; that these junior officers be detailed for engineering work exclusively; and he includes in his estimates $250,000 for a testing laboratory and experiment station at Annapolis in the department of marine engineering. Such an establishment would be of the highest value in training cadets in the methods of conducting physical and mechanical tests and obtaining trustworthy and reliable results. A post-graduate course in steam engineering at the Academy would also be of great value.

WORK ON THE 30-FT CHANNEL in the Delaware River to Oct. 22, has been reported upon by the harbor improvement committee of the Philadelphia Board of Trade. Since Jan. 1, 1901, the Virginia Dredging Co. has completed the bulkhead opposite Reedy Island and dredged 1,729,068 cu. yds. of material, though not as much dredging is done as the specifications call for. There is now a 30-ft. channel at Dan Baker Shoals, 20,500 ft. long and from 250 to 450 ft. wide; this gives three miles of deep water navigation over what was previously a very troublesome section of the channel. The committee states that with present methods of performing the work it believes that the entire terms of the contract can be fulfilled in but little more time than the contract calls for.

BANK REVETMENT ON THE LOWER MISSISSIPPI RIVER.*

By Charles Le Vasseur.†

Before 1879, when Congress appointed the Mississippi River Commission, the Government works carried out on the Mississippi River were not revetment works proper. These works were more to control and rectify the channel, or to close chutes, and consisted chiefly of piles, dykes and training walls. The policy was then to force all the water of the river into one main channel.

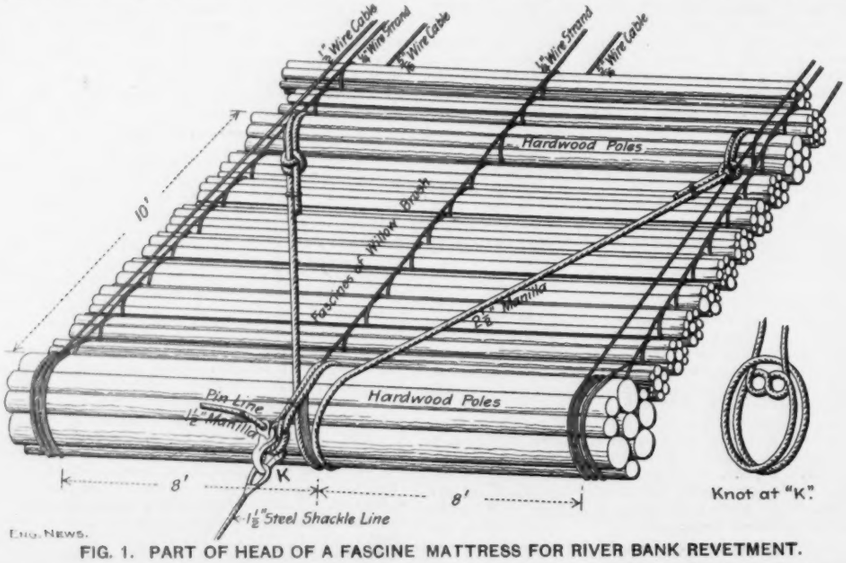


FIG. 1. PART OF HEAD OF A FASCINE MATTRESS FOR RIVER BANK REVETMENT.

The first continuous revetment work was done in 1878. It was only a protection of the bank under low water. It was anticipated that the bank above low water would not need to be protected and would take care of itself.

This revetment consisted of a mattress 150 ft. long by 50 ft. wide, built on ways erected on a barge. These ways had inclined skids or runs 6 ft. apart supported by posts and extending 6 ft. beyond the edge of the barge. The mattress was composed of a longitudinal bottom crib or layer, made of poles 6 ins. in diameter at the butt, secured by wire and spikes 8 ft. apart to cross-set of stringers of same dimensions. All intersections of this crib were provided with vertical pins of hickory, 1 in. in diameter and 3 ft. long. This bottom crib or layer was covered by five layers of small willow brush, placed each layer at right angle to the one above or below, and of a total thickness of 2 ft. On top of these layers of brush was set a top crib similar in construction and dimensions to the bottom one, secured to pins by wedges, nails and wire. The mattress completed, ropes were fastened to it in such manner as to be freed by toggles when at the bottom. Then the mattress was launched from the ways and towed to the site of the bank to be protected. When in position rock was thrown from barges to sink it in place. Such a mattress protected 150 ft. of subaqueous slope. Its cost was about $18 per lineal foot.

It was found in 1880 that the upper slope exposed to the current action was needing protection. For this reason the bank was then graded to a slope of 45° and covered by a matt 8 ins. thick, fastened to the ground by wire tied to "dead men." It was expected that this upper-slope mattress would soon be covered by sediment during high stages of the river.

This method of matt construction was entirely modified in 1881. The poles, crib frames at top and bottom and the hickory pins were replaced by wire netting fastened by wire stitches passing through the matt. Under the netting longitudinal poles were placed 8 ft. apart to assist in launching, and on top cross rows of piles were wired to the mat. These poles formed pockets, preventing the ballast rocks from rolling off during the sinking.

The mattress, on the slope above low water, was also loaded down with rip-rap stone. During that year the slope grading was done by means of hydraulic jet for the first time.

The next fiscal year, 1882, the mattress construction underwent other changes. The type of mattress adopted was what is known as "woven mattress." These mattresses were built in continuous lengths of from 500 to 2,000 ft. and sunk. For this method of construction the entire plant had to be altered. A mooring barge 170 ft. long by 26 ft. wide was placed, end on to the bank, at the upper end of the bend to be revetted. This barge was secured in position by manila ropes leading to "dead men" on shore or to anchors in the stream. To this mooring barge, on its down-stream side, the floating ways were secured by 1-in. rope. The mattress was built on the floating ways and was composed of a layer of 30-ft. willow poles, lapping from 4 to 6 ft., fastened together with No. 12 wire and 6-in. spikes, and placed across the runs near their water ends. Longitudinally between the runs, about 6 ft. apart, were placed poles of the same dimensions, with their large ends resting on the transverse system and the whole was tightly wired and secured together. These constituted the weaving poles. On top of these a set of poles similar to the first was laid transversely, wired and spiked. This formed a matt-head. Willow brush was then woven over and under the longitudinal poles, the brush being about 30 ft. long and from 3 to 4 ins. at the butt. Each woven line of brush extending the whole length of the floating ways was tightly fitted to the matt-head and to the preceding one by means of mauls.

This weaving process was continued until the 30 ft. of poles was filled with woven brush. Space enough was left to spike and wire other poles. Every 30 ft. of mattress completed was launched. For this the lines holding the floating ways to the mooring barge were slackened and the ways dropped down stream under the matt. When the length required to protect the bank was built the sinking took place. After the mattress was sunk it was secured in place by piles driven through its near shore edge. The upper slope bank was then graded and revetted with willow mattress placed diagonally between two frames of poles 10 to 12 ft. apart, well secured together by No. 8 wire and spikes. When the upper bank revetment did not lap the subaqueous matt, a connecting matt was built overlapping both shore and river revetment. The shore matt was covered by rock in quantity sufficient to destroy its buoyancy. The cost of this work was about $14 per lin. ft.

From 1883 to 1893 this method of revetment was improved at nearly every working season, but in the main the construction was the same. The manila rope fastenings were replaced by wire cables. The plant, mooring barge and floating ways were changed and altered to follow the different modifications in the constructions. In 1890 this method of "woven mattress" was perfected as far as such construction could be. I will be permitted to mention here that this revetment had become a standard work and that its different and successive improvements were mainly due to the suggestions of Aug. J. Noiry, one of our members. After observations and investigations of the results of this bank protection it was found that in some places the outer edge of the matt was undermined by the current and that the mattress, not flexible enough in its construction, thus had not adapted itself to the new condition of the channel. The works were thus in danger of being destroyed by the undermining action of the current.

For this reason the Mississippi River Commission decided to strengthen the matt, to increase its width and to adopt some kind of fascine matt construction which would be stronger and also more flexible and would accommodate itself to the inequalities of the bottom. From 1890 to 1892 several experiments were made with fascine mattress. These experiments were conducted, if I recollect well, by our President, C. W. Sturtevant. As the results of these experiments it was decided to finally adopt the "fascine mattress" as bank revetment. The materials and plant used in the construction of these mattresses are, with slight modifications, the same as previously stated. The mattress barges or floating ways were provided, underneath the platform, with a number of cable drums, one under each inclined way, on which was wound and from which was payed out as the construction of the matt progressed the steel wire strand which constituted the longitudinal strength of the matt, and to which the fascines were attached or more properly woven. The distance between drums was 8 to 9 feet. On top of the platform fascine formers were placed. The main difference of construction between the early type of mattress and this fascine mattress was the replacing of the bottom and top crib poles by a net of wire strands, so that the flexibility would be increased.

The first operation in the construction of the mattress proper is building the matt-head. This consists of a bundle 2½ to 3 ft. in diameter, made of poles 5 to 8 ft. in length, well bound together by wire strand and forming a beam of great length of some rigidity, but having also a great flexibility. This "matt-head" is as long as the mattress is wide and is moored to the bank by steel wire cables independent of the mooring of the mooring barge. The number of cables used depends on the width of the mattress and the strength of the current. The wire strands, from drums on the mattress ways, are passed over their proper sheaves and secured to the "matt-head." The weaving strands which are ¼-in. steel are also attached to the matt-head, one for each longitudinal strand upon which the fascines are woven. The brush is carried from a brush barge to the former and is placed in two layers with tops in opposite directions and joints broken. Enough brush is put in to make a fascine 10 to 12 ins. in diameter. It is then choked at every run and bound into a fascine by No. 12 steel wire. This fascine having the length of the matt is raised from the formers and skidded on runs to its position next to the matt-head.

The weaving strand is then passed over the fascine down underneath it and up between the fascine and matt-head, crossing at the same time the bottom longitudinal strand. It is then put into a "paren clamp" and drawn taut by means of double block and tackle, the men pulling upstream against the fascine already in place. The strand is temporarily stapled to a pole of the matt-head. The

FIG. 2. A TYPICAL BANK ON THE LOWER MISSISSIPPI.

*A paper read before the Memphis Engineering Society.
†U. S. Assistant Engineer, Memphis, Tenn.

second fascine being in place, the weaving strand is passed over the first and second fascines down underneath the second and up between the first and second, at the same time crossing the bottom longitudinal strand as before. It is again attached to the clamp and drawn taut as before by block and tackle and temporarily stapled to a piece of brush in the first fascine. The weaving and bottom strands are clamped together by a cable clamp every 10 ft. (diagonally), and at points intermediate between the clamps both strands are stapled to the brush to prevent the fascines from separating during the process of weaving.

On top of the mattress thus constructed are placed rows of poles, 16 ft. apart, extending up and down stream. They are lashed to the fascines by No. 7 silicon bronze wire every 5 ft. and at intermediate points by strong steel wire lashings. These poles are to prevent the stone from slipping off the matt when it is sunk on a steep slope, and also by being lashed to the body of the mattress by non-corrosive wire to prevent the displacement of the brush after the steel wire weaving strand and other corrosive connections shall have rusted away.

When the ways are filled the mattress is launched in the usual manner and the construction proceeded with. The brush composing the fascine do not exceed 3 ins. in diameter. One-half and 5-16-inch strands are used for the bottom longitudinal strands, the half-inch size being used at the channel edge of the matt, where the current is greatest and the 5-16 nearer shore; ¼-in. strand is used exclusively for the weaving. The sinking of this fascine mattress is done as follows:

The mattress is first ballasted nearly to the sinking point with rock delivered direct from barges by wheelbarrows on run plank the usual way. The "matt-head," held up to the mooring barge by the "slip lines," is ballasted to its full load and then lowered enough to let the rock barges in and out. These barges are lashed end to end and swung from the mooring barge by parallel 2-in. manila ropes, long enough to pay out over the whole length of mattress. After the first 50 ft. of mattress is heavily ballasted the "slip lines" are lowered away slowly and continuously until the mattress head is on the bottom of the river and all "slip lines" slack. This operation consumes a few minutes of time. Particular care is taken to have the mattress head sink to the bottom without delay, so that the friction of the mattress on the bottom will aid the mooring cables in holding the mattress and to avoid the heavier strain which would result from a submerged mattress waving in the current free from the bottom, a strain which may cause the loss of a mattress. The rock barges are then dropped down over the mattress and the rock is thrown over evenly and continuously.

With the mattress of early type the sinking sometimes required two days. With the fascine mattress, in 30 minutes after the rock barges are across the head of the matt the sinking operation is completed. Paradoxical as it seems, the fascine mattress will be sunk in less time and with less trouble in moderate, even strong current, than in slack water, the current helping to get the matt down and to handle the rock barges to advantage.

Connecting mattress, overlapping the shore and the subaqueous mattress, are also built by the same method.

The slope above low water is not covered by mattress any more, as in the early method, but after the grading is done the slope is paved with 4 to 6 ins. of spalls, overlaid by 6 ins. of stone, extending up the bank to about the 20-ft. stage.

During the experimental stage of the work grading of the slope banks was done with shovels, then with sluice boxing and hydraulic jet. It is done now entirely by hydraulic process.

The hydraulic grader consists of a barge carrying a pumping plant discharging 2,000 galls. per minute under pressure of 170 lbs., with steam pressure of 100 lbs. per square inch, through 4-in. hose to nozzles, the pressure at nozzle being about 125 lbs. The grading is done after the mattress is sunk. The material washed from the bank, fills the inequalities of the ground which may exist at the shore end of the subaqueous mattress. The material used per square (100 sq. ft.) is approximately as follows:

Brush, 1.5 cord; poles, 0.08 cord; stone, 0.75 cu. yd.; wire, galvanized No. 12, 3 lbs.; wire strand, galvanized ¼-in., 6 lbs.; wire strand, galvanized 5-16-in., 4 lbs.; wire strand, galvanized ½-in., 1 lb.; clamps, 5-16-in., 1.35 number; clamps, ½-in., 0.16 number.

To build and sink a matt 1,000 ft. long and 250 ft. wide requires 15 working days with a labor force of 150 men. The cost of matt work completed and sunk is about $17 per lin. ft. of bank. The cost of paving is about $10 per lin. ft. of bank. The total cost of completed bank revetment of this fascines type is $29 to $30 per lin. ft. The grading costs about $1.25 per lin. ft. of bank. The quantity of stone used per square yard of bank paving is about 0.3 cu. yd.

Since the last six years but slight modifications in detail have been made in this form of revetment. It has been found that the stone paving of the slope above low water should be carried to the top of the bank, to prevent the current, during the high stage of the river, cutting the revetment from the shore and thus undermining the works from the rear, as has happened at Bines Point, Mo., and Daniel's Point, Ark., where the revetment, at the foot of O'Donnell's Bend, was left undisturbed, but isolated from the receded bank by a channel about 200 ft. wide, which the current had dug, during the high water stage, between the edge of the reveted slope, and the previous existing top bank. The "fascine mattress" as bank protection, has proven to be a success. The reaches, such as New Madrid, Plum Point, Hopefield, Lake Providence, where this work has been extensively used as bank revetment, and also the different city harbors, Hickman, Ky., New Madrid, Mo., Caruthersville, Mo., Luxora, Ark., Memphis, Helena, Greenville, etc., are a proof of it.

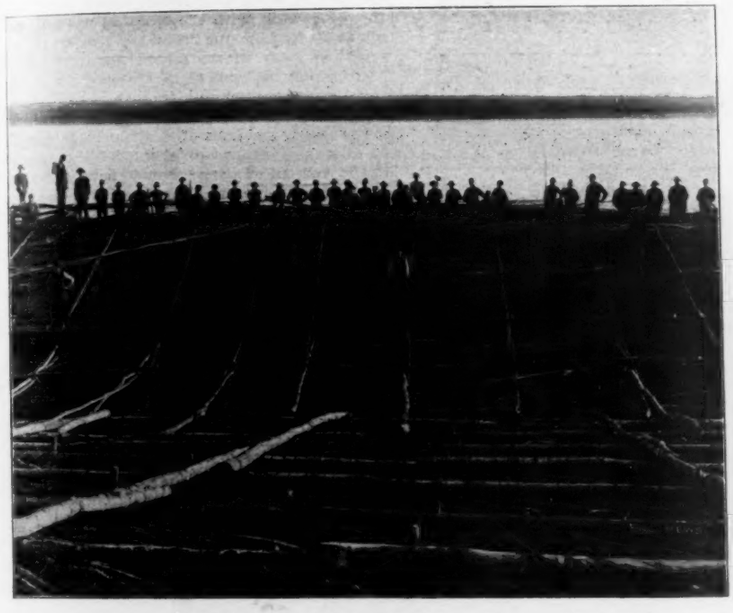


FIG. 3. WEAVING A CONNECTING MATTRESS; WOVEN TYPE.

FIG. 6. SINKING A WOVEN MATTRESS.

MELAN ARCH PARK BRIDGES AT WASHINGTON, D. C.

By W. J. Douglas.*

(With two-page plate.)

In the latter part of October, 1900, work was begun on two Melan bridges, in the District of Columbia, which were completed in the spring of the ensuing year. These are the first concrete-steel bridges to be constructed in the District. Both bridges were built for the United States Government, were designed by the Melan Construction Co., of New York, and were constructed by the Geisel Construction Co., of St. Louis, Mo., under the direction of Capt. Lansing H. Beach, U. S. A., Engineer-Commissioner of the District of Columbia, and Capt. H. C. Newcomer, U. S. A., Assistant Engineer.

The smaller bridge was built across Piney Branch, on the line of Rock Creek Drive, in the National Park, and is shown by Fig. 1. It consists of a single, five-centered arch, having a span of 24 ft. and a rise of 5 ft., with an effective discharge section of 180 sq. ft. In determining the required area for discharge, the Berkli-Ziegler formula was used, with liberal constants, and the calculated area was then increased by about 15%.

On June 2, 1900, during a severe rain storm, an arch culvert, on the site of the new bridge, with a cross-section of about 90 sq. ft., was washed away. Its cross-section was about 10 ft. less than is demanded by the Berkli-Ziegler formula. However, it is not universally agreed among engineers familiar with the case, that its demolition was in any degree due to the small cross-section, but is ascribed by some to other causes. The foundations were not carried more than about 2 ft. below the bed of the stream, and the flow of the water was throttled by a bridge about 50 ft. above the one carried away. The bridge causing the trouble was to have been removed in a few months. It is thought that the abutments of this bridge, not only throttled the flow, but deflected the course of the current, so that the water impinged on one of the abutments of the culvert (the one that failed) at a decided angle. The choking of the culvert with debris was also of decided moment.

The arch of the new bridge has a thickness of 8 ins. at the crown (Fig. 2). It is built of Portland cement concrete and encases nine 5-in. steel I-beams. The facing of this bridge is of good second-class masonry. Dark blue gneiss was used for the arch and coping, and light gray gneiss for the spandrel walls, wing walls and balustrade.

The larger bridge was built across Rock Creek on the line of the Quarry Road in the Zoological Park, and is shown by Fig. 3. It replaced an old bridge of wood and iron, which was unsafe and totally out of harmony with its surroundings in the park. The new bridge has a span of 80 ft., a rise of 14 ft., and an effective floor section of 1,200 sq. ft. This area is about double the area demanded by the Berkli-Ziegler formula with liberal constants. The facing is of cement mortar throughout. One-half-inch of mortar was found inadequate, as the stone occasionally rammed through, but from ¾-in. to 1 in. was entirely satisfactory. The arch is 18 ins. thick at the crown, and is reinforced by 10 steel latticed girders, Fig. 4.

*Engineer of Bridges, Office of the Engineer Commissioner, District of Columbia, Washington, D. C.

The foundations of both bridges were carried to rock. Lehigh Portland cement was used throughout.

Stone and gravel were used in the foundations and abutments in the following proportions (all measured loose): One part cement, three parts sand, three parts screened gravel, and four parts broken stone passing a 2-in. ring.

FIG. 4. A WOVEN MATTRESS IN PROCESS OF CONSTRUCTION ON THE BARGE.

Most of the work was executed between Jan. 1 and March 1, much of it being carried on during freezing weather. The contractor was allowed to lay concrete at a temperature of 26° F., with a rising thermometer, and at 28° F. with a falling one. The sand and gravel were thoroughly thawed, but not intentionally heated above 40° F. Gravel was not used in the arches. The proportions were as follows: One part cement, two parts sand and four parts broken stone passing a 2½-in. ring.

The bottoms of the joists of the Quarry Road bridge center, which were spaced 14 ins. c. to c., were covered with a layer of tar paper, thus forming an enclosed air space 12 ins. deep between the concrete laid against the lagging and the outside air; thus reducing in a larger degree the danger of frost penetration. The outside of the studding of the south spandrel walls was covered in the same manner. For the north spandrel walls the protection was thought inadequate, and instead of paper, 1-in. boards were nailed to the outside of the studding and the space thus formed between lagging and outside boarding was filled with manure. The top of the fresh concrete was covered, at night, with two layers of tar paper and one layer of cement bags. In no case was the concrete or mortar facing damaged by frost.

In placing the concrete it was attempted to chute it a vertical distance of 25 ft., on a pitch of 45°, but with poor success. The mixed concrete was shoveled into a square chute having a cross-section of 1 sq. ft., and constructed of undressed lumber with no gate to dump the concrete in batches, and without a hopper at the bottom to keep the material from coning and spreading. It was agreed to allow the contractor to use a metal-lined, semicircular chute provided with a gate and hopper, as this arrangement had been found satisfactory on other work in chuting concrete a much greater distance, without any practical separation of the concrete, provided he cleaned the chute each night to insure smoothness, and laid the metal lining true and even, without projecting shoulders.

The arch of the smaller bridge was constructed in a day. The concrete was placed in layers of about 3 ins. and thoroughly rammed with iron rammers weighing 17 lbs., and having a base area of 36 sq. ins. A 10-in. rammer having the same weight per square inch of base would weigh 47 lbs. These rammers were used on both bridges, and it is thought that the concrete was exceptionally well rammed. On the Quarry Road bridge two ordinary iron railroad tampers were used to ram the concrete beneath the lower flanges of the beams and between the lacing, with effective results.

The arch of the larger bridge was constructed in longitudinal sections, each including two girders. The adjacent sections were not bonded together, except by the cement. Each section was completed in about seven hours. The entire arch was constructed in five days.

The centers of both bridges rested on piles driven to hard pan (Fig. 5). Levels were taken during the construction of the arches, and as no measurable distortion of the centers was found, the loading of the crowns was not resorted to. The center of the smaller bridge was removed in 26 days. Prior to striking the center it was observed that the arch had already left the lagging, in consequence of which it was not surprising that the wedges were readily driven out with a 1¼-lb. hammer. The center of the larger bridge remained in place 31 days. The center was lowered ¼-in. at the crown on the first [illegible] the arch following the lagging) and ¼-in. th[illegible]nd day. As the wedges did not tighten an[illegible] lagging was free, the center was removed [illegible]he third day. There was no appreciable dis[illegible]n of the smaller arch after striking. The [illegible] of the larger bridge lowered ⅜-in. at th[illegible]own, and three days afterward rose to its or[illegible] height. Levels taken on July 31, 1901, show [illegible] it is still at the same elevation. The balustra[illegible] was built prior to striking the centers.

No expansion joints were made o[illegible] smaller bridge. In the larger bridge ½-in[illegible] expansion joints, filled with tar paper, were c[illegible]ucted at the intersection of the wing walls wi[illegible]he spandrel walls, Fig. 4. As an additiona[illegible] precaution against the cracking of the spandrel [illegible]alls, iron stiffeners, consisting of two 2-in. ste[illegible]bars, fastened together every 4 ft. of their lengt[illegible] were encased in the concrete, Fig. 6. These stiffeners were placed within about a foot of the bottom of the coping. They were not built continuously across the whole spandrel wall, but were made in two sections, extending from the intersection of the wing walls with the spandrel walls to points about 10 ft. from the crown, leaving 20 ft. of the spandrel walls, at the center, unreinforced. One foot beyond the ends of each stiffener was an expansion joint, extending from the extrados of the arch to the bottom of the coping.

The coping and base of the balustrade were built in alternate sections of about 4 ft., to allow for the movement of the arch and spandrel walls. A layer of tar paper was inserted between adjacent sections. The balusters and rail were molded away from the bridge site, except one section of the rail between consecutive posts, which was cast in place to complete the work. Half-inch lead joints were used where the rail of the spandrel abuts against the two posts, which are directly over the expansion joints at the intersection of the spandrel and wing walls.

One part of lamp black to 12 parts of cement was used in the facing mortar, which was composed of one part cement and two parts sand. The facing sand was washed and screened bank sand which passed through a sieve having eight meshes to the linear inch. This facing mortar, which averaged ¾-in. in thickness, was carried up with the concrete.

FIG. 5. A FASCINE MATTRESS UNDER CONSTRUCTION.

On all straight work, sheet-iron plates about ⅛-in. thick, 10 ins. deep and 5 ft. long, were used in order to facilitate placing the mortar. The

plates were kept ¾-in. back from the forms by temporary strips of wood. The mortar was placed between the plates and forms and carefully worked down with trowels. Concrete was at the same time placed and rammed on the outside of the plates, and as the work progressed the plates were raised, but not withdrawn, about 4 ins. remaining below the top of each consecutive layer of concrete; until the completion of the wall, or the end of the day's work. Where these plates could not be used, as in case of the coping and soffit of the arch, the mortar-face was spread against the forms with a trowel with satisfactory results. It is thought, however, that where possible, these iron plates should be used in preference to wooden plates or troweling, as their use makes it impossible for the stone of the concrete to reach the lagging before the facing mortar is in place. Stiff mortar was used throughout, but grout has been used in connection with iron plates, on other work of a similar character, with equally good results.

The forms for all exposed surfaces were of tongued and grooved pine, coated with boiled linseed oil. Dressed lumber was used instead of rough lumber surfaced with plaster of Paris, on account of the coldness of the weather. After the forms were removed the exposed surfaces were floated up with a cork float, using little mortar, just enough to fill the air holes in the face and give a coat not greater than 1-16-in., composed of one part cement and two parts sand, using fine sand, which would pass through a sieve having 20 meshes to the linear inch. This coat was floated on immediately after removing the forms, and after thoroughly wetting the exposed surfaces. The entire structure was then washed and brushed over with cement grout containing coloring matter in the same proportions as the ¾-in. facing coat and the 1-16-in. surfacing coat.

No broken stone was used in making the balusters, although so stipulated in the specifications, as it was found impracticable. They were built of cement and sand throughout. A piece of gas pipe was inserted on each baluster when cast, to give additional strength. The forms used for the balusters were of cement and plaster, and were carefully cleaned and oiled each time, prior to molding a baluster. Wooden molds were used for all other work. The balusters were allowed to set three days before removing the molds. Twenty molds were used in casting the 236 balusters.

The bases of a number of balusters, when taken out of the molds, were defective (with broken corners) and were patched up when green. It was not thought advisable to use these patched balusters, and all of them that could be detected were discarded. Five of the balusters now in place have the corners of their bases cracked, and it is thought that these were patched balusters, which escaped detection. The balusters were "floated-up" with a thin coat of mortar, using fine sand, as was done for the facing of the bridge.

Paint was tried as a coating for the wooden forms, but was found inferior to linseed oil, as it adhered to the cement and discolored it. Broken quartz was used in the concrete for part of the west abutment of the Quarry Road bridge, but in consequence of its smoothness and hardness, the mortar had but little affinity for the stone and several additional turns were required in making concrete with it. Quartz was, therefore, abandoned after a day's trial as unsatisfactory. No machinery was used on the smaller bridge other than two hand-pumps. A pile-driver and one steam pump were the only machines used on the larger one. It is thought that a concrete mixer would have been economical on the larger bridge. The average cost of mixing and placing the concrete on this bridge was $1.25 per cu. yd., of which amount about 75 cts. was properly chargeable to the mixing.

Neither bridge shows any cracks in the spandrel or wing walls up to the present time, Sept. 16, 1901. In fact, no cracks of any kind have appeared, excepting in case of the five balusters previously referred to.

After the mortar face was completed, a heavy rain caused the entire north facade of the bridge (the facade exposed directly to the rain) to become discolored by the efflorescent material in the cement. This discoloration was not uniform, but in streaks and blotches, which seriously marred the appearance of the bridge. The bridge presented much the appearance of a partially snow-covered structure, and after a half-dozen rains the snow-white color changed to a dirty streaky yellow which was very offensive to the eye. It was thought necessary to clean the structure, and experiments were made in order to determine the most practical and economical method.

Wire brushing, using water freely, was found impracticable. There were 250 sq. yds. of facing to be cleaned, and it was estimated that with this method it would cost $600 to clean the entire structure. Furthermore, the cleaning was not satisfactory. Hydrochloric, acetic and oxalic acids were then experimented with, in conjunction with common scrubbing brushes. All of them were effective. Hydrochloric acid was the best, requiring less scrubbing. Acetic acid came next in efficiency. Hydrochloric acid was used and was entirely satisfactory. Thirty gallons of acid and three dozen scrubbing brushes were required. The acid was diluted with four or five parts water to one part of acid. Water was constantly played with a hose on the work while being cleaned to prevent penetration of the acid.

One house-front cleaner and 5 laborers were employed on the work. Its total cost was $150, or 60 cts. per sq. yd. This high cost was due to the difficulty of cleaning the balustrades. It is thought that the cost of cleaning the spandrels and wing walls did not exceed 20 cts. per sq. yd. The bridge at present shows no signs of discoloration excepting small blotches below the coping of the south facade, which are hardly noticeable. The District Inspector of Asphalts and Cements analyzed the flour which was removed by wire brushing and found it to be a silicate of lime.

The Piney Branch bridge was completed April 1, 1901, and the Quarry Road bridge on April 15, 1901. The total cost of the former was $3,170, and of the latter $21,500, both including royalty, engineering, inspection and all incidental expenses connected with the work.

FIG. 7. UPPER BANK REVETMENT (OLD METHOD) READY FOR STONE.

FIG. 8. UPPER BANK REVETMENT COMPLETED.

TRAIN RESISTANCE FORMULAS.

By John G. Crawford.*

It is not the purpose of this article to discuss the various component parts of train resistance, but to take up the subject as a whole, with special reference to the resistance of that portion of the train behind the tender. In substance, this article is an abstract of the train resistance chapter of the thesis of the writer and Geo. W. Ristine, Jr., presented to Cornell University, for the degree of Mechanical Engineer in June, 1901. The writers of this thesis were assistants on the Chicago, Burlington & Quincy R. R. tests referred to in the latter part of the article, and a number of train resistance formulas were collected for comparison with the formula derived by the writer of this article.

The earlier formulas for train resistance and a few of those derived in recent years were deduced from experiments on slow speed trains, hence it is no wonder that they do not hold at speeds three or four times that of their experimental limits. Many of these formulas have been used and advocated long after their period of usefulness had passed.

The relation of resistance to speed has been expressed in various forms, as will be seen on examining the formulas here collected. Any general formula with the necessary variables and constants to fit any case would be very complex. It is probable that with no wind, the resistance of a train running on a straight and level track without change of speed might be expressed by the formula,

$$R = a + b\,V + c\,V^2;$$

*4131 Drexel Boulevard, Chicago, Ill.

where a, b, c and n are constants; V = the velocity, and R = the resistance of the train at the speed V. With chosen constants this formula would be applicable only to a certain class of trains.

In the first place, it must be decided whether the formula is to include the resistance of engine, tender and cars, or of the cars alone. The loading of the cars must be taken into account, for the resistance per ton of loaded cars would be less than the resistance per ton for the same cars empty. This is due to the decrease in the coefficient of journal friction with increase of load, and also to the fact that the atmospheric resistance is the same whether the cars are empty or loaded. Another consideration, which, like the previous one, involves the relation of weight to volume, is that of the comparative weights of the cars.

A number of various formulas for train resistance are here given, and it is interesting to note that the general tendency from year to year has been to give lower values for train resistance, especially at the high speeds. Fig. 1 is a diagram showing graphically the comparison betweeen various formulas.

In comparing any two formulas the conditions of the experiments on which they are based should be considered.

The following notation is used:

R = resistance in lbs. per ton.
V = velocity in miles per hour.
L = length of train in feet, exclusive of engine and tender.
T = weight of train in tons, exclusive of engine and tender
E = weight of engine and tender.
A = area of frontage in square feet.

Unless otherwise stated, tons are 2,000 lbs.

Where formulas are given in metric units the notation is as follows:

V = velocity in kilometers per hour;
R = resistance in kilograms per tonne.

Formulas given in long tons and metric units are followed by their equivalents in short tons.

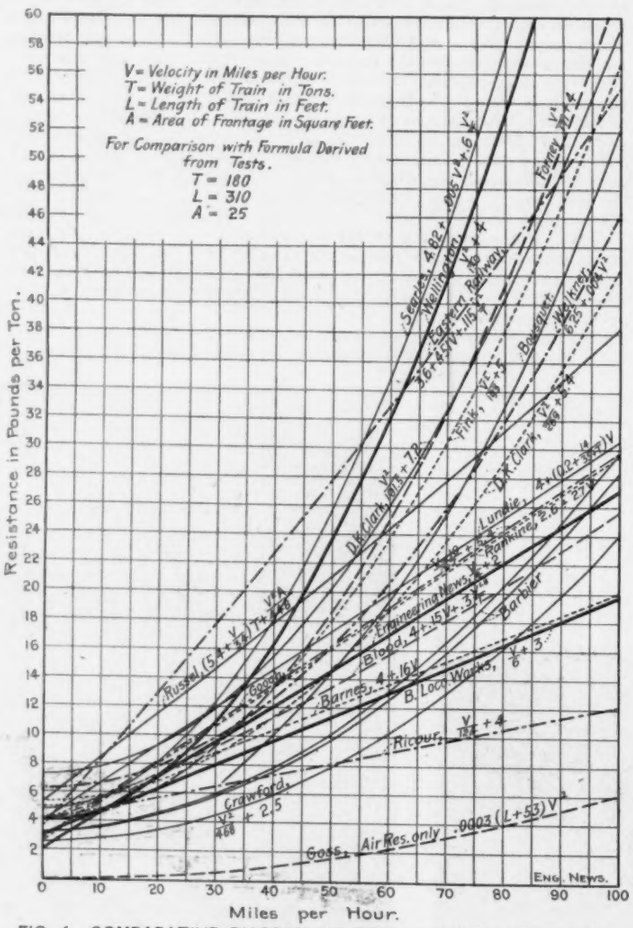

V = Velocity in Miles per Hour.
T = Weight of Train in Tons.
L = Length of Train in Feet.
A = Area of Frontage in Square Feet.
For Comparison with Formula Derived from Tests.
T = 180
L = 310
A = 25
Resistance in Pounds per Ton.
Miles per Hour.
Scarles, 4.82 + .005 V² + .6 V²/T
Wellington, V²/130 + 4
Express Railways, V²/130 + 4
Forney, V²/172 + 4
Boulvin, 2.5 + .001 V²
Ricour, V²/193 + 4
Frink, 3.6 + .4 V + .15 V²
Barbier, V/6 + 3
D. Clark, V²/171 + 8
D. K. Clark, 4 + (.02 + 12/L) V²
Engineering News, 2.5 + .03 V²
Blood, 4 + .15 V + .32 V²
Barnes, 4 + .16 V
B. Loco. Works, V/6 + 3
Russel, (5.4 + 3.6/L) V + V²/240
Crawford, V²/468 + 2.5
Goss, Air Res. only .0003 (L + 53) V²
ENG. NEWS.

FIG. 1. COMPARATIVE DIAGRAM OF TRAIN RESISTANCE CURVES REPRESENTING VARIOUS FORMULAS.

Of the above curves the following are mentioned by Mr. John B. Blood in the "St. Ry. Journal," of May, 1899: Scarles' formula of $4.82 + .005\ V^2 + .6\ \frac{V^2}{T}$ is the formula given in this article reduced by Mr. Blood to include only resistance of cars. The Eastern Railway formula is for speeds ranging from 43 to 50 miles per hour. Welkner's curve was derived at low speeds. Rankine's formula, R = 2.6 + .27 V, and Blood's, are given in the above-mentioned article.

Upper Barbier curve is drawn as published in the "Railroad Gazette." The lower curve was reduced from the original formula by Ristine and Crawford.

The curve marked Bousquet was drawn from a table of resistance published a few years ago.

The curve marked Barnes, R = 4 + .16 V, is one attributed to him and is not drawn from the accompanying table.

D. K. Clark gives in his book "Railway Machinery" the following formulas for long tons.

Engine, tender and train,

$$R = \frac{V^2}{171} + 8 \text{ (Long tons).}$$

$$R = \frac{V^2}{191.5} + 7.2 \text{ (Short tons).}$$

Train alone,

$$R = \frac{V^2}{240} + 6 \text{ (Long tons).}$$

$$R = \frac{V^2}{269} + 5.4 \text{ (Short tons).}$$

These were published in 1854, and were based on the experiments of Mr. Gooch, which covered several years. The experiments were made on the wide gage (7-ft.) roads, at low speeds, and general conditions were not favorable to easy running.

In Rankine's "Civil Engineering" is found this formula, given by Mr. Gooch for train, exclusive of engine and tender,

$$R = 6 + \frac{V - 10}{3.3} \text{ (Long tons).}$$

$$R = 5.4 + \frac{V - 10}{3.7} \text{ (Short tons).}$$

The formulas of Rankine, as given in his "Useful Rules and Tables" are similar to D. K. Clark's and according to conditions take any value between the following limits,

$$R = 2.7 + \frac{V^2}{540} \text{ (Long tons).}$$

$$R = 2.4 + \frac{V^2}{605} \text{ (Short tons).}$$

and

$$R = 8 + \frac{V^2}{180} \text{ (Long tons).}$$

$$R = 7.1 + \frac{V^2}{202} \text{ (Short tons).}$$

A reference to Mr. Scott Russell's formula is found in Van Nostrand's "Engineering Magazine" of 1877, page 490. This formula is for the train, exclusive of locomotive, and takes separate account of head resistance,

$$R = \left(6 + \frac{V}{3}\right) + \frac{V^2 A}{400\ T} \text{ (Long tons).}$$

$$R = \left(5.4 + \frac{V}{3.4}\right) + \frac{V^2 A}{448\ T} \text{ (Short tons).}$$

Wellington, in his "Economic Theory of Railway Location," gives Searle's formula for resistance of entire train,

$$R = 4.82 + 0.005357\ V^2 + \frac{.0004783\ V^2 L}{T + E}$$

Wellington, as a result of his tests made on the Lake Shore in 1878, gives for loaded freight cars,

$$R = \frac{V^2}{130} + 4.$$

These tests were made at speeds under 30 miles per hour, and the "drop test" system was used.

Mr. John B. Blood, in the "Street Railway Journal" of May, 1899, gives this formula as Wellington's,

Total Res. = 4 (T + E) + 0.28 V² + 0.03 V² C + 0.005 V² (T + E); where C = number of cars.

Beginning at the left, the terms represent journal friction, head resistance, side atmospheric resistance, and resistance due to concussion and oscillation.

Boulvin, in "Cours de Mécanique Appliqué aux Machines," gives a formula derived by Frink, a Prussian engineer, which applies to train alone,

$$R = 2.5 + 0.001\ V^2 \text{ (Metric units).}$$

$$R = 5 + \frac{V^2}{193} \text{ (Short tons).}$$

Ricour, in 1885, gave for the resistance of the train alone,

$$R = \frac{V}{40} + 2 \text{ (Metric units).}$$

$$R = \frac{V}{12.4} + 4 \text{ (Short tons).}$$

Ricour's formula is given in Wellington's "Economic Theory of Railway Location."

Forney, in an article published in "Scribner's Magazine" of March, 1892, gives a curve whose formula is,

$$R = \frac{V^2}{172} + 4.$$

As it is so near Clark's formula, it probably includes resistance of engine and tender.

D. L. Barnes, in the "Engineering Magazine," in 1894, gave a curve for train resistance at speeds from 50 to 100 miles per hour. It is said to have been derived from the results of tests on the C., B. & Q. R. R., and the Pennsylvania R. R. The experimental range of this curve is probably from 50 to 70 miles per hour. The following table gives the various resistances,

V	50	60	70	80	90	100
R	12.0	12.4	13.5	15.0	17.0	20.0

Barbier, in "Le Génie Civil" of April 8, 1898, gives the following formula for cars alone,

$$R = 1.6 + 0.456\ V \left(\frac{V + 10}{1000}\right) \text{ (Metric units).}$$

$$R = 3.2 + 2.36\ V \left(\frac{V + 6.21}{1000}\right) \text{ (Short tons).}$$

These experiments covered a period of four years (1891-1895), and were made in all seasons of the year. The speed range was from 30 to 60 miles per hour. The weight of trains, exclusive of engine and tender, ranged from 120 to 210 tons, and the average weight was 160 tons.

Prof. W. F. M. Goss, in the "Railroad Gazette" of May 20, 1898, gives the results of tests on model cars, $\frac{1}{32}$ actual size, to determine the effect of air resistance. The following formula gives the resistance offered by still air to that portion of a train which follows a locomotive tender:

Total Res. = 0.0003 (L + 53) V².

The Engineering News' formula is,

$$R = \frac{V}{4} + 2.$$

This includes all resistance except the internal frictional resistance of the locomotive. The curve

represented by this equation at speeds of from 60 to 70 miles per hour, was determined by indicator cards taken on the engine hauling the "Empire State Express." The curve at low speed was determined by taking the average results of various tests.

The formula used by the Baldwin Locomotive Works is,

$$R = 3 + \frac{V}{6}.$$

It was derived from indicator cards taken on a Vauclain four-cylinder compound, and hence is

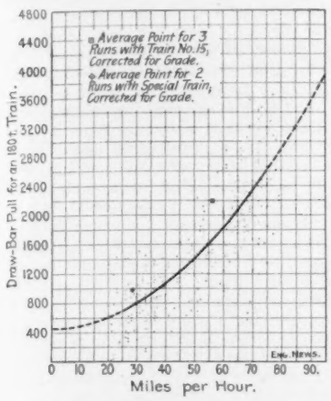

Average Point for 3 Runs with Train No. 15, Corrected for Grade.
Average Point for 2 Runs with Special Train, Corrected for Grade.
Draw-Bar Pull for an 180 t. Train.
Miles per Hour.
Eng. News.

Fig. 2. Train Resistance Records and Curve.

Each point represents ½ mile; corrected for grade and acceleration.
Train No. 15 weighed 180 tons.
Special train weighed 160 tons.
Points from special runs reduced to 180-ton equivalents.

for engine, tender and train. The data were obtained on three runs on the Atlantic City Railroad from Camden to Atlantic City, a distance of 56 miles. The trains were made up as follows:

(1) A six-coach train, two of which were Pullman's.

(2) An eight-coach train, three of which were Pullman's.

(3) A twelve-coach train, four of which were Pullman's.

Mr. John Lundie, from experiments on the South Side Elevated Ry., of Chicago, deduced the following formula,

$$R = 4 + V\left(0.2 + \frac{14}{35 + T}\right).$$

See "Street Railway Journal," March, 1899.

In these experiments, the "drop test" system was used. The trains ranged in weight from 21 to 82 tons, and the upper limit of speed was only 26 miles per hour. The formula includes resistance of motors, and is probably useful only in electric railway work.

In July, 1900, some tests were made on the Chicago, Burlington & Quincy R. R., under the direction of Mr. Max H. Wickhorst, Engineer of Tests, to determine the cost of running trains at high speed. The tests consisted of five runs from Chicago, Ill., to Burlington, Ia., a distance of 206 miles. Three runs were made on fast mail train No. 15, its schedule running speed being 55 miles per hour; and two runs were made on a special train of the same make-up, but run at half the speed. The fast mail train consisted of dynamometer car, two baggage and two mail cars, its total average weight behind the tender was 180 tons. The special train consisted of similar cars, carried no lading, and averaged 160 tons.

The dynamometer paper furnished a continuous record of speed and drawbar pull. This paper feeds 1 ft. per mile, and on that account it was convenient for the purposes of planimetering to divide the paper into half-mile sections, and then find the mean drawbar pull for each half-mile section. An electrically-operated time pen recorded each five seconds, and from this record the speed in miles per hour was computed for each half-mile.

In order to reduce the probability of error to a minimum, for finding the speed-drawbar pull curve, only those portions of the dynamometer paper were selected, which showed that there had been little change of the speed of the train in the run of the half-mile, and where the grade correction would also be small. No correction was made for the curvature, but all the observations on heavy curves were omitted. In obtaining some of the extreme speeds it was necessary to make considerable grade correction. Of the 2,060 values of speed and drawbar pull, only 333 were used in finding a relation between speed and drawbar pull.

Since the dynamometer paper feeds 1 ft. to the mile, the number of spaces of 1-60-in. which can be interposed between the marks representing five seconds gives the speed in miles per hour. Thus the speed of the train, on entering and leaving a half-mile block was found. The difference in height of the track between the beginning and end of the half-mile block was found from the profile of grades. Hence, knowing the change of velocity of the train and its rise or fall in the half-mile, acceleration and grade corrections are found. Each of the 333 points, representing 166.5 miles, was corrected and plotted, as shown in Fig. 2. The points surrounded by squares represent the average drawbar pull and speed from Chicago to Burlington. Burlington is 80 ft. lower than Chicago, and this grade correction was made, but these average points include resistance of curves and lost energy due to use of brakes.

The points are seen to be scattered on either side of the line drawn to represent their mean. This is caused by errors in the acceleration correction, but as consecutive sections of the dynamometer were selected, a positive error in one block is a negative one in the next, and hence they tend to balance. The curve given in Fig. 3 is that of Fig. 2, reduced to lbs. per ton.

The points in each half-mile column were averaged, and note made of the number of points represented in the average; then the weighted mean was drawn, and the equation of the curve was found to be,

$$R = \frac{V^2}{468} + 2.5.$$

This equation was derived from experimental data representing 166.5 miles of running. As the speed range was from 25 to 75 miles per hour it cannot be expected to hold for low speeds; also

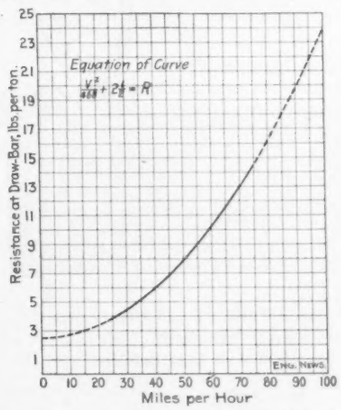


Fig. 3. Train Resistance Curve Derived by John G. Crawford.

Checked by Geo. W. Ristine, Jr. Certified by Prof. R. C. Carpenter.

it cannot be expected to hold for all classes of trains. As will be seen by reference to Fig. 1, it compares favorably with Barbier's experiments, which were made in all seasons of the year, while those on the C., B. & Q. R. R. were made when the mean temperature of the atmosphere was 70° and the wind was very light.

THE ORLING-ARMSTRONG SYSTEM of wireless telegraphy now interesting London, is the joint invention of Ariel Orling and J. T. Armstrong. Only newspaper accounts have as yet appeared and these must be taken with caution. But the claim is made that the ground and not the air is used for transmission; no tall masts are required as in the Marconi system, the electric installation is "simple and cheap;" and the inventors claim that no interference is possible, as the pitch can be varied to 40,000 fones, no one of which will conflict with another. It is claimed that the apparatus can be used for telegraphing, telephoning, or for power transmission.

A STATEMENT BY MR. M. W. KINGSLEY, M. AM. SOC. C. E., LATE SUPERINTENDENT OF THE CLEVELAND WATER-WORKS.

Many of our readers were doubtless surprised to learn, a few weeks ago, that Mr. M. W. Kingsley, M. Am. Soc. C. E., had been dismissed from his position as superintendent of water-works at Cleveland, O. The causes for his dismissal were not given, but Mr. Kingsley subsequently made a statement to the Cleveland "Plain Dealer" regarding the political and other difficulties which hampered him while in office. Believing that the many friends of Mr. Kingsley, as well as all those who are struggling under like burdens, will be interested in the statement, we reprint it below, as follows:

While I was nominally superintendent of water-works, and held before the people as being responsible, the department was practically run by my superiors. I was not permitted to employ or discharge a man, and in cases where I would suspend an employe for good and sufficient cause, he would afterwards be reinstated contrary to my desires. While I should have been at liberty as superintendent of the department to have given my time to the superintending of the works, I was confined at the office at clerical work from three-quarters to seven-eighths of the time, to do the work which a competent clerk, familiar with the work, could have done, had I been permitted to employ such a person. The fact is, that politics, and not business, runs the institution. The best man I ever had who could have done all this clerical work, thoroughly, competently and faithfully, was discharged against my wishes, and a political "pet" put in his place, who had no experience in this class of work. On leaving the department he was employed by one of the leading business houses of the city to take charge of their office work. He is still with them, and they tell me that he is the most competent man they ever had in that position. I simply give this as an illustration of the difficulties I had to contend with.

The water department is blamed for holding up street improvements. As an illustration, bids were received for valves and contract held up months before approving it or allowing it to be approved. In the meantime paving was put down and it will have to be ripped up again to put in a valve, which we might have had in ample time had ordinary business methods been carried on. Water connections are ordered by the city engineer on all streets where street improvements are made, and the city receives bids for doing this work, and the work is not done by water-works without special order. Of course, it is an easy matter of keeping executive control well in hand, when the director ignores the head of a division and asks for a special report from the employes, as was done recently: One case for a special report on Shaft No. 4, from one employe; another report on lowering an engine from another employe.

What Mr. Kingsley says about being overburdened with clerical work is wholly in accord with the observations of a member of the editorial staff of this journal who has had occasion to visit Mr. Kingsley's office several times during the past few years. The impression received was that both Mr. Kingsley, and his assistant Mr. Schultz, were the two most badly overworked men that the observer had ever met in his journeyings among municipal officials.

THE NASH GAS ENGINE.

We illustrate herewith two of the Nash gas engines, built by the National Meter Co., of New York city, which are in operation in the Pan-American Exposition at Buffalo. The larger engine, rated at 125 HP., drives through a belt the pump supplying the large volume of water for the electric tower, and the smaller one, rated at 50 HP., is direct-connected to a dynamo furnishing current for light and power. Fig. 1, showing a cross-section, is of the 125-HP. engine, but it may be taken as representing also the 50-HP. engine, since both engines have the same general construction.

The Nash engine is of the four-cycle, vertical, enclosed, self-oiling type, and is built with one, two or three cylinders, all of the cylinders being of identical construction. The cylinders are separate castings, independent of each other, and are mounted on the crank case which encloses the connecting rods, main bearings and other working parts. All of these are lubricated by the oil contained in the base being dashed over them when the engine is in operation. Provision is also made for lubricating them independently by an automatic sight-feed oiler.

All cylinders are water-jacketed on the sides, heads and valve-cases; they are drained at the lowest points, and so constructed as to be easily repaired or replaced.

The single-acting trunk pistons act also as cross-heads, and are therefore made of great length in proportion to their diameter.

The crank shaft is in one piece of forged open-hearth steel, cut from the solid. It runs in ad-

justable bronze boxes, so arranged that each crank has a bearing on each side.

The connecting rods are forged from open-hearth steel, the crank end being of the marine type, with adjustable boxes, of hard bronze, while the end connected to the trunk piston is formed into a solid eye bushed with bronze, easily renewed when necessary. Owing to the liberal proportions and thorough lubrication of the bearing at the piston end, so little wear occurs that no other adjustment is needed.

It will be noted by the cuts that all the valves and the whole valve motion are conveniently located on the working side of the engine. A single-cam shaft drived by a pair of spur gears operates all the valves through levers and rollers. Each cylinder has its own admission, gas and exhaust valves, the admission valve A being shown with its cam B, roller C, and lever D, and the gas valve E, with a pawl, F, engaging a toe G, carried on the admission valve stem, so that either both of these valves open together, to admit a charge for the power stroke, or else the governor, H, acts to disconnect the pawl, the gas valve remains closed and no charge enters until standard speed is restored, according to the well-known principle of regulating by missed ignitions. Whenever a charge is missed the admission valve still permits air to enter, which is compressed, expanded and exhausted, cooling the cylinder and cleaning it of any remaining products of combustion.

The exhaust valve is located immediately behind the admission valve, and the exhaust connection, J, with its flange, appears at the upper right-hand of the cylinder. Immediately below this is the flanged opening, K, by which gas enters the mixing chamber, and surrounding the upper part of the gas connection is an annular opening, L, through which air passes and is mixed with the entering gas for a charge.

The valves are made of drop-forged steel with long stems, carefully fitted to bearings and guided at top and bottom, thus securing an accurate seating without any side springing to occasion wear and leakage. Inserted valve castings are not used in the Nash engine, since experience has shown them to become so distorted by heat as to either leak or break. Moreover, it needlessly complicates the design and renders efficient cooling of the valve case and valves much more difficult. In the light of long experience the builders of the Nash engine have so designed the cylinder and valves that after the first regrinding, performed some time after the engine is started, the valves wear so slightly and become so little coated with carbon that no further attention is required for a long while, sometimes a year or more.

Electric igniters of the make-and-break type are attached to each cylinder, as shown in the cut, being operated by separate eccentrics carried on a shaft, M, located on the side opposite to valve motion, and driven from the cam shaft by means of a cross shaft and two pairs of miter gears. The igniters are independent of each other and are provided with means of adjustment to accurately time the ignition, as desired, without stopping the engine.

A special form of fly-ball governor, driven by bevel gearing from the cam shaft, is used for these engines. It operates by the method of missed ignitions, and secures a remarkably steady speed even under wide variations in the load. The governor is very sensitive, especially because it does not operate the gas valves directly, but simply indicates by the position of the lever, to which it is connected, whether or not the lifting pawl shall act to open the gas valves or keep them closed, as demanded by the load upon the engine. Each cylinder has its own gas valves, and is governed independently of the others.

The 50-HP. engine has three cylinders, each 9 ins. diameter and 11 ins. stroke; the speed is 270 revolutions per minute. The 125-HP. engine has three cylinders, each 13½ ins. diameter and 16 ins. stroke, operating at 225 revolutions per minute. It will be observed that these speeds are quite moderate, although the vertical type of engine would safely permit considerably higher ones.

Each of the engines shown in the cuts is provided with a suitable self-starting device, operated by compressed air, since they are too large to be conveniently started by hand. The air starter consists essentially of an air compressor, an air reservoir and suitable valve mechanism to operate one of the cylinders by compressed air. The action is as follows: A single movement of the starting lever, shown at the left hand in the cut of the 125-HP. engine, throws into action supplementary cams, so that the right-hand cylinder operates as a single-acting, compressed air engine, while the other two are placed in position ready to start up with gas. As soon as speed is attained by means of the first cylinder, and ignitions occur in the other two cylinders, the starting lever is moved back to its normal position, the air-starting mechanism is disconnected, and the machine operates as a gas engine.

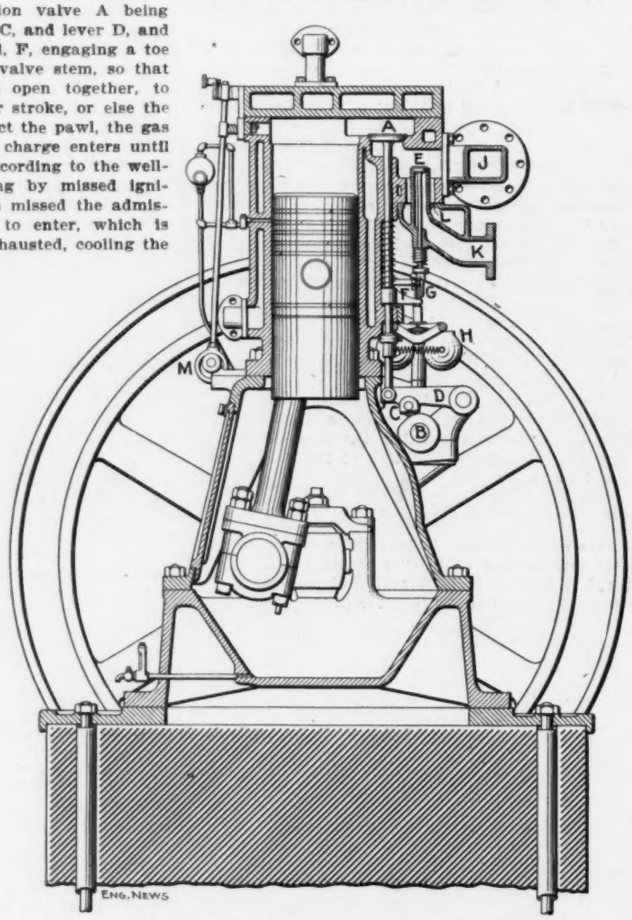


FIG. 1. SECTION OF NASH GAS ENGINE OF 125 HP., SHOWING DETAILS OF VALVE MOTION.

National Meter Co., New York City, Builders.

THE CONTROVERSY OVER THE SETTLING reservoirs for the new water-works for Cincinnati appears to have been settled by the offer of the original contractor, Mr. August J. Henkel, to complete the work undertaken by the subcontractors, R. M. Quigley & Co. The contractor is to be paid for conglomerate in excess of 60,000 cu. yds., as outlined in our issue of Oct. 17.

THE TRIALS AND OPPORTUNITIES OF A CONTRACTING ENGINEER.

In the last issue of "The Polytechnic," of the Rensselaer Polytechnic Institute, Mr. George E. Gifford, M. Am. Soc. C. E., a member of the class of '87, refers to some of the trials of a contracting engineer and to the advantages of a technical training. As this now important branch of the profession of engineering seldom appears in print, some abstracts are made from his article.

In the carrying out of contract work the great requisite is to secure the contract, and in this connection Mr. Gifford points out the advantages to a contractor of a thorough engineering training. The fixing of item prices and methods of work are almost wholly matters of experience and judgment. But the accurate determination of quantities in a large piece of work is very important, and in this estimate the contractor cannot afford to make a mistake. Here the trained engineer has a great advantage, and after some practice in this class of work preliminary estimates can be prepared with remarkable accuracy. Mr. Gifford notes a recent case, where, in bidding for six railway bridges—no two alike in design—the finished weight was estimated at 1,332,000 lbs., and a lump sum contract was based upon this estimate. The actual shipping weight of these six bridges was 1,330,411 lbs. This estimate, however, was unusually close in its agreement with actual weights, especially when it is considered that no rolling mill will undertake to roll with a less variation than 2½% of figured weights.

Mr. Gifford says that the above estimate was based upon very carefully prepared plans issued to the bidder, and remarks that present busy conditions do not favor the old-time practice of simply sending out specifications and requiring bidders to furnish their own designs. The companies now following this custom are likely to receive scant attention, as the contractor can figure upon plenty of work requiring far less trouble and time. The great advantage to the purchaser of complete plans is the receipt of a greater number of close bids.

The writer notes among the tricks of the buyers of bridges the following: A bridge-building firm secured, at its own expense, data for making the plans for a number of bridges requiring replacing on a line of railway and submitted designs and bids for the same. Though the proposal was supposed to have been accepted by the railway company and a contract was about to be entered upon, the chief engineer of the bridge company later found blue prints of his design submitted to rival concerns, with a request to bid upon them.

Another plan of the buyer is to reject all bids as "unsatisfactory," and then to filch the good points of each design submitted and invite bids upon "our own plans and specifications." Still another scheme—actually put into operation by a great municipality in the State of New York—was to advertise the letting of a piece of public work in ten days. On applying for plans, the bidder was handed a short printed description of the work, coupled with the information that designs must be submitted by the bidder on his own survey and measurements, and that he was to deposit with a designated official a certified check for an amount equal to about 25% of the cost of the work, which check had to be deposited "five days before the letting." This job was apparently "set up" for some one close to the city officials.

In fixing prices in the preparation of a bid, says Mr. Gifford, the engineer-contractor requires all the judgment and experience that he can gather from a study of past work of a similar character, market values, controlling conditions affecting transportation, labor, etc., special machinery required to facilitate his work, and special risks that have to be considered.

In connection with special appliances for performing work and for skill shown, the engineer-contractor receives scant recognition from the public, and even from engineers. When a great structure is completed the press will tell you all about its financial promoters; probably give you the name of the chief engineer, and will applaud it as a magnificent engineering feat. But it frequently happens that the actual erection of the structure demands even more technical ability and the application of a sounder judgment and

more common sense than did the preparation of the original design. But the erector, who is necessarily a contractor-engineer, is rarely mentioned in such cases. It is the contractor who must worry about possible accidents from fire, storm and floods, and plan to meet such contingencies, and not the consulting engineer. In the nine cases where disaster has been averted by the precautions taken by the contractor, or by the pluck, energy and experience with which he meets an imminent peril and just succeeds in saving the structure, we hear nothing about it. But in the one case where all his efforts fail the public know all about it, and most likely condemn his "foolhardiness" in taking risks.

In conclusion, Mr. Gifford believes that no field offers more opportunities to the man who is technically trained and is endowed with brains and adaptability than that of general contracting. This belief is well supported by the increase in recent years of large contracting firms composed wholly or in part of engineers.

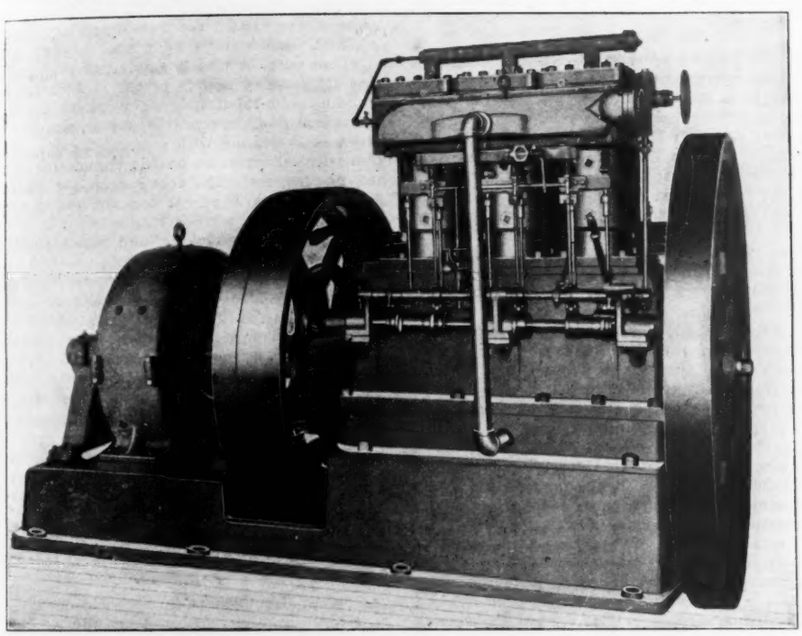


FIG. 2. VIEW OF 50-HP. NASH GAS ENGINE.

BOOK REVIEWS.

SMOLEY'S TABLES; Containing Parallel Tables of Logarithms and Squares of Feet, Inches and Fractions of Inches Expressed in Decimals of a Foot and Advancing by One-Thirty Second of an Inch from Zero to Fifty Feet. By Constantine Smoley, C. E. New York: Engineering News Pub. Co. 1901. Leather; 4¾ × 7 ins.; pp. 212; $3.

The character and purpose of this book are quite clearly indicated by the title. As stated, the tables give both logarithms and squares of feet and fractions of a foot. It differs from such tables as Hall's, first, in covering distances of from zero to 50 ft. instead of from zero to 100 ft.; second, in giving squares of feet and fractions thereof varying by 1-32-in. instead of by 1-16-in.; third, in giving the logarithms of feet and fractions in addition to their squares, which alone are given by Hall. The tables are introduced by an explanatory preface, and the volume concludes with a number of typical examples showing the method of using the tables.

HOW TO BUILD A 3-HP. LAUNCH ENGINE.—By E. W. Roberts, M. E., Cincinnati, O. The Gas Engine Publishing Co. Cloth; 10 × 13 ins.; pp. 64; 14 plates. $2.50.

The author of this volume has already appeared before the public with an excellent "Gas Engine Handbook." The present book is essentially a collection of complete working drawings of a 3-HP. launch engine, designed in accordance with the principles and formulas laid down in the "Handbook." The drawings are for a four-cycle gasoline engine to run at 350 r. p. m. and developing at that speed from 2.9 to 3.5 HP. All parts are so constructed that they are readily machined and finished with the tools available in an ordinary small machine shop. Accompanying each plate is a chapter giving a full explanation of the drawings, for the aid of those not adept at reading drawings, and valuable hints and suggestions for every step in the completion of the parts, making the patterns, molding, machining, etc. In getting up the drawings, complete shop drawings were first made, full size or to a large scale, and these were reduced to make the plates. After the drawings and chapters of explanation for all the different parts, including an 18-in. propeller wheel, we find an erection drawing with the most minute directions as to setting up and adjusting, a chapter on testing the adjustments and the working of the parts, and a drawing with description, giving all details incident to installing the engine with its oil tank and fittings in a launch. The engine is so constructed as to be just suitable for a 20-ft. launch whose detailed construction is described in "How to Build a Motor Launch," also published by this company. It will propel such a launch at speeds up to 7½ miles per hour. Anyone desiring to build a gasoline engine for launch or other use will find this book of great value. The plates are excellent reproductions and the only criticism that might be made is that the lettering and dimensioning on the original drawings might well have been more neatly done. Realizing that copies of the drawings for shop use might be desired in order to preserve the book from injury, the publishers are prepared to furnish a set of blue prints of the original working drawings for the price of $4.50. The book, together with such a set of prints, is sold at $6.50.

CHIMNEY CONSTRUCTION (DER SCHORNSTEINBAU).—By Gustav Lang, Professor at the Technical High School of Hanover. Hanover: Helwingsche Verlagsbuchhandlung. Part III. Paper; 7 × 7¾ ins. pp. 189 to 338; 2 plates and 90 cuts. Price, $2.70.

This is the third part of a work of some magnitude on chimney construction and is devoted to the erection of masonry chimney shafts. The first part took up the subject of the Proportions and Dimensions of Chimneys; the second, the Cross-sections, Distribution of Expansion, Effect of Heat and Wind Pressure.

Part III. is divided into five chapters, of which the first, devoted to the shaft, occupies 87 pages. It considers the subject in all of its phases: the shape, the variation of dimensions from the base to the top, the strengthening of the wall, the materials and the method of binding, the use of hollow brick, a comparison of three forms of cross-section (the square, octagonal and round), rules for the designing of simple chimneys, accompanied by the solution of a number of examples, chimney linings, protection against the cracking of chimney masonry, and various forms of clamps. Nearly all of these topics are illustrated and many are accompanied by elaborate mathematical demonstrations.

The second chapter is devoted to the chimney cap, in which the purposes of the same are stated to be two-fold. The turning of the wind currents in such a way that they shall tend to increase rather than check the draft, and the protection of the masonry below against injury and deterioration. It is illustrated by drawings and half-tone illustrations taken from several American sources, and the method of construction is entered into in detail.

The third chapter deals with hoods for chimneys and is accompanied by several illustrations of decorative caps. In the fourth chapter, the artistic features of chimney construction are considered and several illustrations of decorative chimney work are given, among them the beautiful stack on the Avenue de la Bourdonnais in Paris, and the well-known one at the spinning mills in Chemnitz. The fifth chapter is devoted to foot-holds and ladders, in which the methods of fastening to the brick work in order to secure the best results are carefully discussed and illustrated.

The two plates at the end of the book are detailed drawings of two chimneys in which there is a diagrammatic calculation of the stresses to which they would be subjected, both as to weight and wind pressures, accompanied by a side elevation and sectional details. A serious drawback to the book is the total lack of either table of contents or index.

THE MARCONI WIRELESS TELEGRAPH, on Oct. 22, enabled communication to be established between the Cunarders "Campania" and "Lucania," when these ships were about 170 miles apart. A large number of messages were transmitted; and one from a passenger of the "Campania" was sent by wireless telegraphy to Brow Head, on the Irish Coast, and cabled back to Philadelphia, reaching that city 24 hours before the "Campania" arrived at New York. Another cablegram sent from London to a passenger on the "Campania" arrived too late to reach the ship at Queenstown; but it was sent to the wireless station at Crookhaven, and from there transmitted to the passenger at sea.

AN IMPROVED FORM OF ACCUMULATOR designed for high capacity for given gross weight and increased durability with special reference to motor-car work, is manufactured in France. The electrodes consists of cylindrical, rod-like elements held together in tiers by lead connection plates at top and bottom. The elements are made by forming an annular layer of lead paste on a core of hard lead wire or rod, and subsequently spinning a covering of asbestos thread around the composite pencil. The spinning of the covering as well as the forming of the layer of paste is done by special machinery, the latter operation with the use of great pressure. The electrodes in a finished cell of this type weigh nearly half the total gross cell weight; capacities of 18 to 26 watt hours per kilogram gross weight have been obtained, depending upon the rate of discharge.

AN AUTOMOBILE RECORD of 10 miles in 11 mins. 9 secs. was made by Alexander Winton on the Grosse Pointe race-track, at Detroit, Mich., on Oct. 24. Mr. Winton used a heavy racing machine and lowers by two-fifths of a second the record made by Henri Fournier, on the Empire City track on Oct. 10.

PATENTS ON AN ELECTRIC VAPOR LAMP have been recently issued to Peter Cooper Hewitt. The inventions relate to lamps in which an ordinary commercial current produces incandescence in a gas enclosed in a tube or bulb. Methods are described and claimed as new to facilitate starting of the lamp, to regulate the lamp automatically in the case of slight variations of terminal pressure, and to obtain a satisfactory quality of light. The latter object is accomplished by using nitrogen and mercury vapor in the lamp, the proper combination giving a light that is soft and pleasing in effect. The patents relating to starting of the lamp state that certain substances when introduced into the tube seem to decrease the resistance at starting while passing out of action during subsequent operation of the lamp. Sulphur is such a substance, and sulphide of mercury introduced into the tube at the time of its manufacture will accomplish the purpose. The lamp will be started by a current of higher e. m. f. than the operating current, but acting for only a very short space of time. Some combinations of coils and interrupters are given that will automatically produce such a starting flow. A metallic band around the tube near the cathode also facilitates starting. The automatic regulation is based upon the fact that gases have a density of maximum conductivity. The heating effect of the current path is utilized in connection with the radiating capacity of the tube for the purpose of so varying the density as to control the resistance, and consequently the current flowing, sufficiently to ensure satisfactory operation.

IRON-STONE DUST WITH TRAP-ROCK MACADAM is being tested by the City of Province as pavement. The iron-stone dust, ranging in size from ¼-in. to dust proper, contains about 40% of magnetic iron, and it was used as a binder mixed with 1-10th part of limestone dust. The State Chemist of Connecticut stated his belief that this iron dust would oxidize and form a coating over the macadam. To test this binder, other sections of pavement in the same street were laid with the same macadam and different binders, including fine black gravel, Diamond Hill quartz-dust, field-stone dust and trap-rock dust; tarred macadam was also tried. To date, this whole pavement is wearing well, with the tarred macadam wearing best of all. The oxidating of the iron-stone dust and lime is not apparent. Some of this class of pavement has been laid over two years in Providence, and has proved very satisfactory.

TYPHOID FEVER MORTALITY IN CHICAGO was abnormally high during the third quarter of the current year. No satisfactory explanation of the increase, so far as we know, has been offered.

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, - - - - - - - - - PRESIDENT.
D. McN. STAUFFER, - - - - - - - VICE-PRESIDENT.
CHARLES WHITING BAKER, SECRETARY AND MANAGING EDITOR.
F. P. BURT, - - - TREASURER AND BUSINESS MANAGER.

WM. KENT, E. E. R. TRATMAN, } ASSOCIATE
M. N. BAKER, CHAS. S. HILL, } EDITORS.

A. B. GILBERT, - - - - - - - ASSISTANT MANAGER.

CHAS. W. REINHARDT, - - - - CHIEF DRAFTSMAN.

ALFRED E. KORNFELD, New York,
M. C. ROBBINS, Chicago,
S. B. READ, Boston,
C. F. WALKER, Cleveland,
} ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.
CLEVELAND OFFICE, OSBORN BUILDING.

FOREIGN AGENTS.

C. MITCHELL & Co, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE. 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $7.00 (31 shillings); Thin Paper Edition, One Year, $6.31 (26 shillings). SINGLE COPIES of any number in current Volume, 15 cents.

In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 321 means that subscription is paid to the 32d week (that is the issue of Aug. 8) of the year 1901; the change of these figures is the only receipt, unless one is sent by special request.

ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

Another mayor is agitating the "free water" idea. A few years ago the late Hazen S. Pingree attracted no little attention throughout the country, and made all sorts of trouble for the men directly responsible for the administration of the Detroit water-works, by advocating so-called free water in that city. Now it is Mr. J. A. Johnson, Mayor of Fargo, N. D., and a past-president of the League of American Municipalities, who has emblazoned the "free water" motto on his political banner. In a long letter published in both the Fargo "Morning Call" and "Argus" of Sept. 13, Mayor Johnson makes this statement:

> There is no more reason why the citizens should pay a special water tax every 90 days than that they should pay a special tax for the use of paved streets or sidewalks.

Every one who has been responsible for either the operation or the financing of a water-works plant knows the time has not yet come for placing the whole cost of the water-works service on the general tax levy. The two most fatal objections to the plan are: (1) The difficulties that would thereupon arise in the control of water waste, and (2) the impracticability of raising sufficient funds to provide pure water in sufficient quantities. Even the present fixture rates for water prevent a vast amount of waste, and the moderate use of the meter system is far more effective. The removal of all charges for water would also remove all practicable restrictions on waste. Furthermore, most cities find it hard enough now to keep pace with the demands for more and purer water, even when they have the water revenues to fall back upon. If a further charge on the already overburdened taxpayer were substituted for the charge made to those who use water, it is not difficult to imagine the predicament in which many of our water boards would find themselves.

We cannot say how it is now, but according to "The Manual of American Water-Works" for 1897 the city of Fargo at that time paid nothing for water used by the various municipal departments. That is to say, the private consumers paid not only for the water they used themselves, but also for the fire protection and other public uses to which water was put. If Mayor Johnson wishes to institute a beneficial reform, we suggest that he first of all remedy the injustice which accompanies such a practice. If he will accompany this by a readjustment of the rates charged private consumers, so each will pay in proportion to the amount of water used or wasted, he will find the cost of water for both domestic and manufacturing purposes so reduced as to be a burden to none. At the same time he may rightly expect the people of Fargo to rise up and call him a public benefactor, which is more than is to be expected in case his "free water" plan should be put into effect.

The city bacteriologist of Minneapolis, according to a local newspaper, is earning his salary nowadays. In a single trip down the river he is reported as having discovered a dead sheep "moored alongside a log," while near the mouth of one of the water-works intakes, in the language ascribed to him by the newspaper reporter, "was the biggest rat I ever saw, dead or alive." The paper does not state whether the bacteriologist goes out on such expeditions armed with a microscope or a shotgun. Incidentally, the story in hand does state that the bacteriologist took ten samples of water for analysis, but lest the interest of the readers should lag, it hastens to add that "he saw some weird and disquieting things in the water." These "things," the story goes, "did more than his professional work to discourage him in using water from the West Side station."

The newspaper lesson drawn from this inspection is that one of the city's pumping stations should be moved to a point on the river where the water is less polluted. However this may be, it certainly would be well to construct the filtration plant recommended years ago by the city's engineering advisers, and now being urged by some of the citizens. The typhoid statistics of Minneapolis indicate that there are worse things than dead sheep and immense rats in its water supply. We presume the local press has found talk of such minute organisms as typhoid bacteria futile, and that in prosecuting its campaign against impure water it has felt compelled to place something less diminutive and more tangible than disease germs before the readers.

While the Minneapolis newspapers have been trying to arouse public sentiment against the present foul condition of the water supply by setting forth its zoological contents, as above noted, a Chicago paper has been belaboring the health department of that city for its dilatoriness in showing whether or not the water supply of a portion of Chicago known as Rogers Park is responsible for an epidemic of scarlet fever in that section of the city. Both instances are forcible illustrations of the ignorance of the general public regarding the dangers to health and life which constantly beset them. An occasional dead sheep in a water supply will create great indignation in a community which day after day complacently drinks its own or its neighbor's sewage. A hue and cry over a water supply as an alleged source of scarlet fever or diphtheria is frequently raised when it is an improperly guarded milk supply, deficient or no medical inspection of schools, or lack of isolation of patients and disinfection of sick rooms, that should be attacked. The vast amount of wasted energy due to erroneous ideas concerning the way epidemics of disease are spread would, if properly applied, go far towards eradicating many of the communicable diseases which now claim their thousands of victims each year.

Property rights in trade names have recently been sustained in a suit tried in the United States Circuit Court in the Northern District of California. The suit was brought by the Babcock & Wilcox Co., of New York city, against a manufacturer in San Francisco to restrain him from using the name "Babcock & Wilcox" in connection with steam boilers which he made and sold. The suit was decided by Judge Morrow in favor of the plaintiffs on the ground that by their long use of the name Babcock & Wilcox they had acquired property rights in it, so that the name could not truly and lawfully be used to designate goods made by other concerns.

That this decision is in the interest of the public is almost self-evident. If a manufacturer or merchant or any producer or dealer in commodities builds up a reputation for fair and honorable dealing, for high-class goods and excellent workmanship, he ought to be protected in the use of that name, and what is even more important, the public ought to be protected against a competitor who would trade on the reputation thus obtained to further the sale of goods elsewhere produced.

Conspicuous examples of the fraudulent use of trade names are all the time occurring. Several Wall St. bucket-shops have adopted firm names identical with, or closely similar, to the names of leading banking houses of the highest financial standing and reputation. The ignorant country speculator who answers these advertisements supposes he is dealing with a world-famous institution with whose name he has become familiar in the newspapers. The fraud upon the public in such a case is apparent enough; but a similar fraud is involved whenever an attempt is made to sell goods of any sort or kind under a label or name, which misleads the buyer.

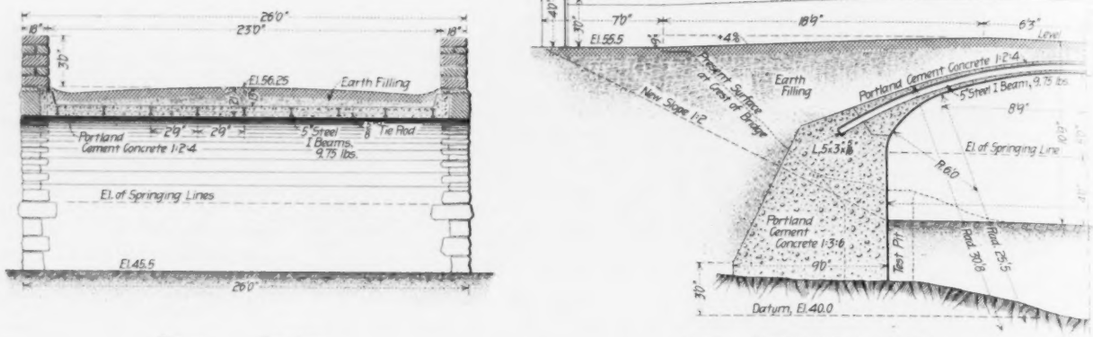
Successful imposition of this sort, moreover, puts a premium on such frauds, and discourages every man and every firm who seek to build up an honest reputation for themselves. Why should they take the trouble to deal honestly and give good value to their patrons, if the reputation thus acquired may be traded upon by any new rival who is unscrupulous enough to adopt such means? But it is manifestly good public policy to encourage honesty and fair dealing in trade and commerce. Hence we have another reason in support of court decisions sustaining property rights in trade names.

TERMINAL PROBLEMS OF INTERURBAN ELECTRIC RAILWAYS.

A recent development in electric transportation is the interurban electric railway operating along the public highway, or, less frequently, on a private right of way, and connecting a number of neighboring towns and cities. These interurban roads are susceptible of division into several classes, but they all differ from the city road proper in the following principal particulars: They run large cars at comparatively high speeds and they carry in many instances freight as well as passengers. Naturally these differences have made necessary different car and track construction, and different mechanical and electrical equipment generally than are required on city roads. These mechanical and structural problems have been generally recognized by engineers, and their solution, as our readers know, has received much careful study for a number of years. They do not, however, constitute the whole problem of the interurban electric railway.

It is becoming constantly more evident to those who have followed the progress of interurban electric roads that a set of problems has gradually grown up in conjunction with their structural and mechanical development, whose solution is quite as important and is pressingly demanded by street railway managers. These problems are distinctively transportation or operating problems, and particular attention has been recently directed to them in a paper by Mr. Ira A. McCormick, General Manager of the Cleveland City Ry., Cleveland, O., read at the last annual convention of the American Street Railway Association in New York city (Eng. News, Oct. 17). This paper and the discussion which followed it are of too special interest to warrant their publication in full, but they suggest a number of questions of more general interest which it seems desirable to review.

To summarize briefly, Mr. McCormick's paper was devoted specifically to a consideration of the traffic relations between interurban electric railways and the city electric roads with which they connect and upon which they in most cases depend for trackage rights into the business cen-



Cross Section. Half Longitudinal Section.

FIG. 2. LONGITUDINAL AND TRANSVERSE SECTIONS OF PINEY BRANCH BRIDGE.

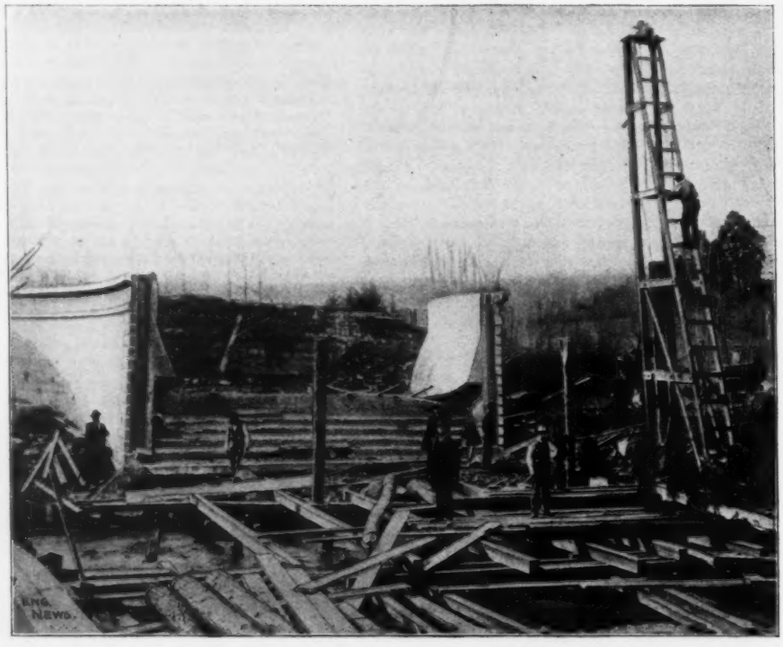
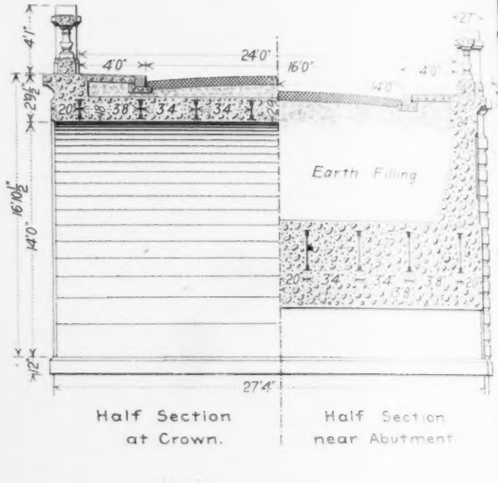


FIG. 7. VIEW OF COMPLETED WING WALLS OF ROCK CREEK ARCH, SHOWING EXPANSION JOINTS AND RECESSES FOR ARCH RING.



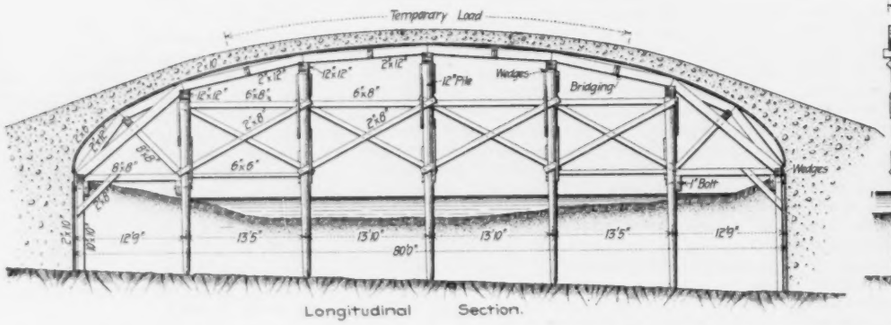
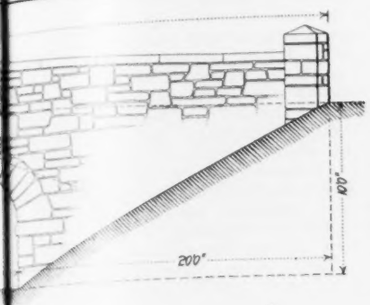


FIG. 5. DETAILS OF CENTERING FOR ROCK CREEK BRIDGE.



Side Elevation.

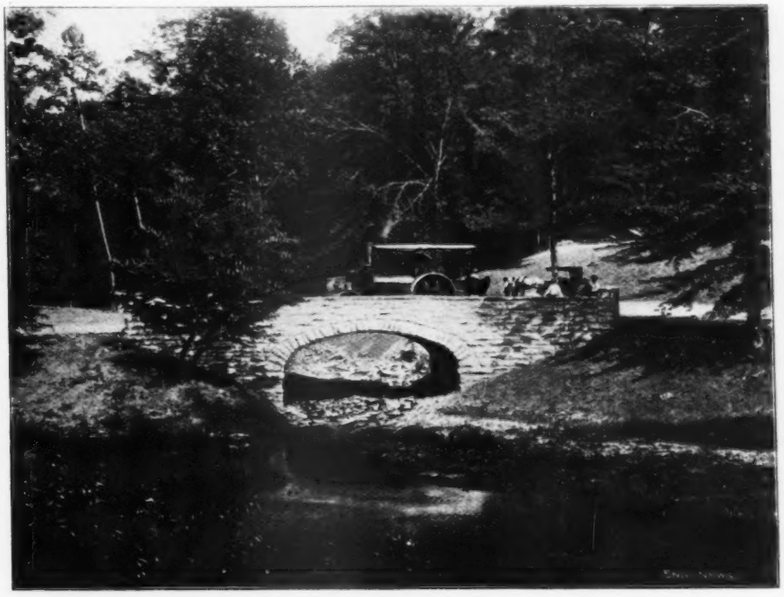


FIG. 1. BRIDGE OVER PINEY BRANCH, NATIONAL PARK.

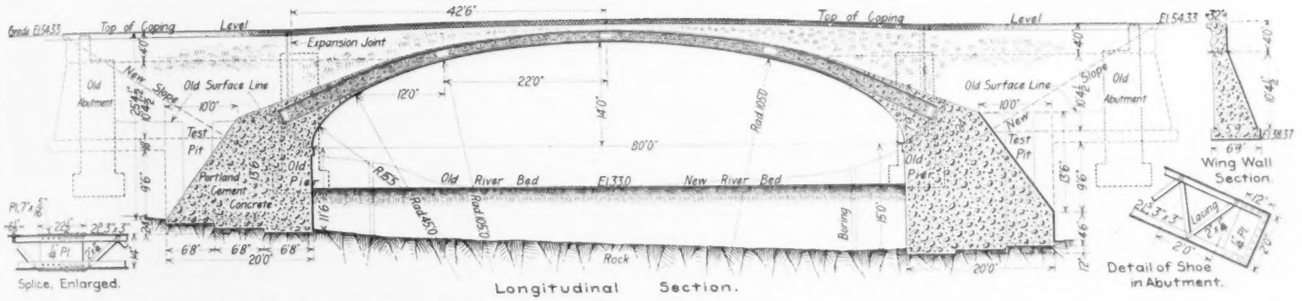


FIG. 4. LONGITUDINAL AND HALF TRANSVERSE SECTIONS OF ROCK CREEK BRIDGE.

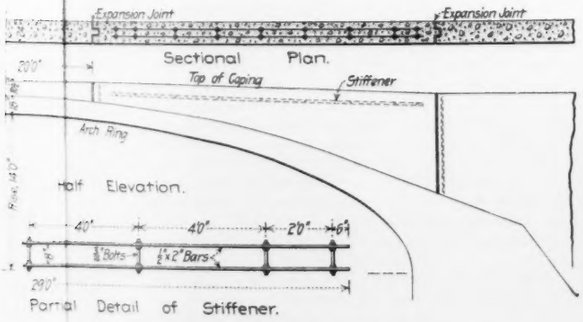


FIG. 6. SECTION OF ROCK CREEK ARCH, SHOWING EXPANSION JOINTS AND SPANDREL WALL STIFFENERS.

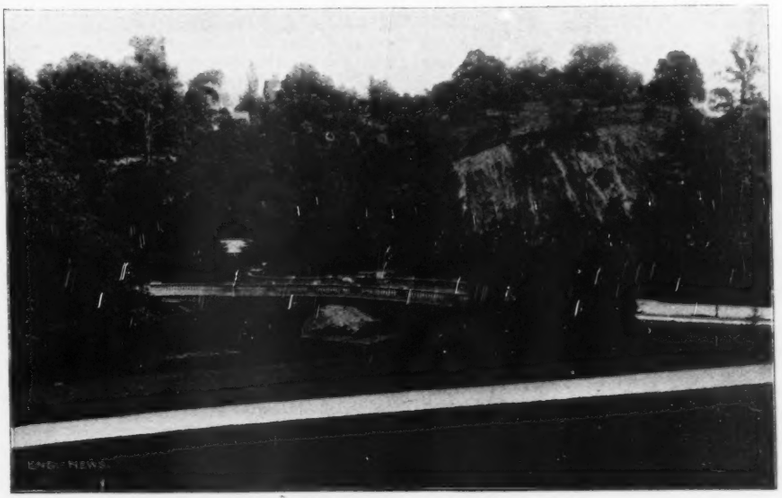


FIG. 3. BRIDGE OVER ROCK CREEK, ZOOLOGICAL PARK.

MELAN ARCH PARK BRIDGES, WASHINGTON, D. C.

Capt. Lansing H. Beach, Engineer Commissioner, District of Columbia.

ters of the towns and cities which they join. It pointed out that in the early days of interurban roads the traffic arrangements required were comparatively simple. They contained an agreement as to the compensation to be paid the city company for permitting the interurban cars to run over its tracks; an understanding as to the crews which were to handle the cars, and as to responsibility for accidents, and other similar matters of detail. The rapid development of interurban roads had, however, it was demonstrated, changed these early conditions. At present managers were confronted by questions of weight and type of cars, of dimensions and gage of wheels, of handling freight, express and mail traffic, of difference of voltage, and of many other matters, which were becoming more and more difficult to adjust satisfactorily, and which had not been dreamed of in the infancy of interurban roads.

A few examples will suffice to illustrate the character and extent of these difficulties. We will take first the matter of unusual weights of cars. Mr. McCormick pointed out that the heaviest of modern city cars weighed from 24,000 to 30,000 lbs., while the latest interurban cars ranged from 35,000 to 60,000 lbs. in weight. Coincident with the increase in the weight of cars there has come increased wheel dimensions. Recent interurban cars have wheels with 2¾-in. treads and 1-in. flanges, as compared with 2¼-in. treads and ⅝-in. flanges for the wheels of city cars. In respect to voltage most city lines operate with 550 volts or less, while interurban lines employ 750 volts or more. Finally, many interurban roads run frequent cars to carry package freight and express matter, and facilities in the shape of depots and sidings are required to accommodate this traffic. These facilities are useless to the city roads. It is evident without further enumeration that, where interurban roads have trackage rights over city lines, the track construction and power plants of the city road are called upon to meet conditions for which they were never designed, with the result that they suffer havoc from the excessive burdens laid upon them. The problem before the managers is: How is this trouble to be remedied?

Before attempting to reply to the question just asked, it is desirable to note briefly what the nature of the solution is, which has so far been attempted. In substance it is one of mutual concession and sacrifice. The city road patiently endures an increased wear and tear on its track and unusual strains on its power plant for the sake of accommodating the interurban road and of sharing in its traffic. The interurban road, on its part, keeps down its car weights and wheel dimensions and reduces the speed of its cars so as not to place an inordinate burden on the track and power facilities of the city line. It does this so that it may obtain the right to enter the city streets and accommodate its traffic. This solution of the problem is but a partial one, and is, as a rule, mutually unsatisfactory. Nevertheless, it is the solution which is almost universally adopted, and the bulk of Mr. McCormick's paper is devoted to a presentation of typical examples and illustrations of its operation. With the details of these we need not concern ourselves, since it is the general principle upon which the solution is based that is of particular interest.

Returning to the original statement of the problem, it seems to us that the first step toward its successful solution is to recognize the fact that there are at least two classes of interurban roads each of which presents different conditions; the second step is to abandon the notion that the interurban electric road can in all cases be considered an extension of the city street railway system. The two classes of interurban roads may be defined quite accurately for ordinary purposes as roads for heavy traffic and roads for light traffic. Interurban roads for light traffic are those which can follow the public highways and will conform to the conditions of travel on these highways. The cars used on these roads do not greatly exceed the heavier city cars in size, and the speeds maintained are not greatly in excess of those for which the heavier city cars can be easily equipped. For all practical purposes of operation and equipment, interurban or suburban roads of this class can be regarded as rural extensions of city lines. Their cars when on the city streets are city cars; they take what comes to them of the regular street traffic and they conform in speed to city conditions. Only when freight cars are run are any special facilities required for the interurban traffic, and these are easily supplied by establishing one or more depots with turn-outs from the city tracks.

Interurban roads for heavy traffic present an entirely different set of conditions. In the discussion which followed Mr. McCormick's paper a number of speakers referred to interurban electric railways running on their own private rights of way, with track construction conforming to steam railway standards and operating heavy double-truck cars on steam railway schedules. As a specific example, mention was made of a road now under construction which will run cars 61 ft. long and weighing, loaded, 45 tons, at schedule speeds of 50 miles per hour. There is no doubt from present indications that this class of interurban roads will have a large development in the future. The main point to be noted, however, is that such roads cannot be considered as extensions of city roads; they approach more nearly steam railway standards, and the problem of terminal facilities for them must be solved by the same rules that apply in steam railway practice. This means that the interurban road must enter the cities which it connects by an independent line, and must have terminals separate and independent of the city street lines. This is demanded not only by the mechanical necessities of the heavy traffic interurban line, but also by the business necessities. It is out of the question to handle any large amount of freight traffic on the city lines, and it is impossible for the interurban cars when on the city lines to run at a higher speed than is established by the regular street car traffic. These same objections apply to a less extent to interurban lines for light traffic, but even here they seem likely to result in the relegation of the interurban cars to certain routes best adapted to give them direct and unobstructed entrance to the business center of the city, and which will have a track construction suited to endure the greater loads and running speeds.

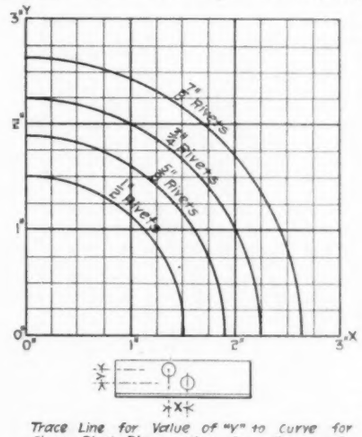
Returning again to the necessities of heavy traffic, interurban electric roads in the way of terminal facilities, and the argument which we have briefly presented to show that they are best met by providing an independent entrance free from the ordinary street traffic, we will conclude our remarks with the following significant quotation from Mr. McCormick's paper:

> The status of interurban railways in years to come is one which few people are willing to prognosticate. Just at present it appears to many people that they occupy, and will continue to occupy, a field which is separate and distinct from that of the steam roads. They are operating from town to town, opening up heretofore isolated country and affording short routes between points which heretofore have been far apart from the fact that they are located on different steam railroads. In this way the electric railroads aid greatly in the development of the country without actually interfering with the business of the steam roads; on the other hand they frequently improve the steam road business. Will this continue to be the situation is the question which plainly is troubling the steam-road people. If the tide of electric trunk-line building can be abated the steam-road people are now clearly willing to share the passenger business by turning over to the electric roads the short-haul traffic. The business which comes from small towns surrounding the larger cities and that which goes from one small town to the next is said to be detrimental rather than beneficial to many of the steam trunk lines. The president of one of the most important steam roads in the country has recently been quoted as saying that it would be money in the pockets of stockholders if the short-haul passenger business could be turnd over to the electric roads. He figures that people could be brought into the larger centers on the suburban cars and from there they could take through fast trains for distant points. He stated also that the increase of freight business consequent with the building up of numerous suburban towns would more than compensate for the loss of the short-haul passenger traffic.
>
> Briefly, the above appears to be the aim of many of the present promotors of electric roads, but it is a well-known fact that there are many others who claim that the day is not far distant when electricity will compete in every way with steam. Some of the roads under construction are being equipped with 80-lb. rails identical with those used on steam roads and speeds of 60 to 70 miles an hour, with through sleeping and dining cars, are freely talked of. An Ohio company (A. E. Appleyard, of Columbus,) has recently placed a contract for electric sleeping cars which will be placed in operation within the next ten months between Cincinnati and Columbus. Within as many months the Everett-Moore syndicate will have through cars operating from Cleveland to Detroit, and it is the intention to compete for through traffic with the fastest steam road in the country.
>
> Clearly such arrangements can have little in common with the 10-mile an hour schedule which of necessity must remain permanent so long as cars traverse the surface of crowded business and residence streets. Laying aside the question of speed, the electric trunk lines will sooner or later find it to their advantage to handle heavy freight, coal, grain, etc. At present the citizens and city authorities of large cities make little complaint against combination express and package freight cars, or even an occasional exclusive package car, but it is expecting too much to calculate on freight trains transporting merchandise of all sorts through residence streets, even at night.
>
> Obviously, the only solution of the problem under the various conditions mentioned is for the interurban cars to enter the center of the city by means of underground or elevated tracks with special tracks for through cars.

LETTERS TO THE EDITOR.

Diagram for Determining Minimum Alternate Spacing of Rivets for Three Diameters Center to Center.

Sir: I enclose a diagram for determining the minimum alternate spacing of rivets for three diameters center to center. The diagram is self-explanatory. I have used one similar to this for over a year and have found it very convenient. Hoping that through your columns it may find a larger field of usefulness to the profession, I send it for publication. As far as I know the diagram is original with myself. Respectfully yours,



Trace Line for Value of "Y" to Curve for Given Rivet Diam. other Co-ordinate of Curve is Least Value of "X".

Diagram for Determining Graphically the Minimum Alternate Spacing of Rivets for Three Diameters Center to Center.

F. L. Batchelder, C. E.,
With Keystone Plant, American Bridge Co.
221 44th St., Pittsburg, Pa., Oct. 2, 1901.

The Relative Impact of Wheels on Broken and Square Joints in Railway Track.

Sir: Referring to papers presented before the annual convention of Roadmasters, published in the Engineering News of Oct. 10: In the paper presented by Mr. F. J. Allen on the subject of broken joints, there appears the following paragraph:

> In broken joints we do not think the tendency is as great to have low joints for the reason that the blow from passing wheels only acts on one rail while the opposite side is a solid rail, and in this case the joint ties receive only half the force that they get in case of square joints.

The idea I get from the above is that the low joint receives the same blow as if both joints were low. If we investigate this matter it will be readily seen that this is erroneous. When only one joint is low, the body of the car or locomotive (which is the weight that pounds the joints neglecting weight of trucks), drops only one-half as far as if both joints were low. Now, the kinetic energy, or the ability to perform work by a moving body, varies as the square of the velocity (Church, Trautwine and others). Neglecting resistance of air, velocity of falling bodies equals $\sqrt{2\,g\,h}$, or $v^2 = 2\,g\,h$, that is, the square of the velocity varies directly as the distance. Therefore, the blow struck the low joint is only one-half the blow that would be struck that same joint, had the opposite joint been also low, thus, striking one rail half as hard and not pounding the other (assuming, as Mr. Allen does, that the

opposite rail is so rigid that no impression is made by the extra weight). It seems to the writer that we can assume that the shock to the track, in case of one joint being low, is only one-quarter of the amount sustained when both joints are low. This latter assumption may not be good mechanics, but the writer is convinced after an experience of five years with broken joints, using 56-lb. steel and only sandy loam for ballast, with heavy engines, that the cause of joints not getting low is not due to the watchfulness of the section men. Waiving the latter assumption, however, for the sake of theory, it seems almost an axiom that the tendency for low joints with broken joints is only half what it is with square joints. This alone, to say nothing of the better alinement of track on curves, should recommend the practice of laying track with broken joints.

Yours truly,
J. G. Sullivan,
Division Engineer, Canadian Pacific Ry.

Trail, B. C., Oct. 16, 1901.

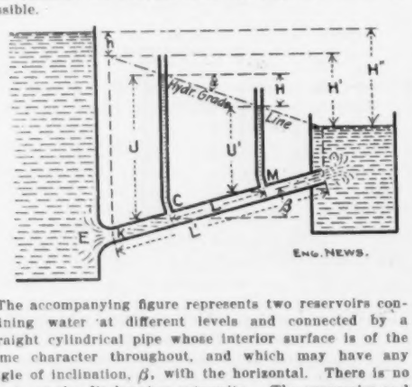
Rational and Empirical Features in Formulæ for Flow in Pipes.

Sir: In Mr. Gould's letter, in your issue of Sept. 12 (p. 179), the question is raised (in the matter of a formula for the flow of water in pipes) whether we are justified in considering that the velocity V is proportional to any other power of the slope S than one-half (that is, can V^2 be otherwise than proportional to S?) because one form of the law of gravitation is $V^2 = 2\,g\,h$.

Mr. Sullivan, also, in his recent work, "New Hydraulics," inculcates the same idea where he says (on p. 38): "It is evident that any formula which causes the coefficient (ratio of S to V^2) to vary in any manner, or to any extent whatever, with a change of head, slope, or velocity, violates the law of gravity which shows that H or S must be directly proportional to V^2 in all cases." Mr. Sullivan is such an ardent advocate of this view that he emphatically discredits any experimental data that are not in accord with it (see pp. 60 and 61 of his book).

In the attempt to build up a rational formula for the flow of water in pipes, to the extent that it is practicable to do so, i.e., up to the point where for further progress recourse must be had to suppositions that are more or less empirical, it would seem preferable to base our efforts on the general and fundamental laws of mechanics and motion which underlie the rational treatment of all cases of bodies in motion, rather than depend on a vague analogy derived from the particular case of the frictionless motion of a falling body. We should hardly contend, for instance, that the velocity of a parachute at the end of its vertical fall through the air, is proportional to the square root of the height of fall, because such is the case for a body falling without friction.

Though at the risk of "carrying coals to Newcastle" as regards many of your readers, the following form of treatment of this problem is briefly presented with a view to distinguishing the rational from the empirical as far as possible.



The accompanying figure represents two reservoirs containing water at different levels and connected by a straight cylindrical pipe whose interior surface is of the same character throughout, and which may have any angle of inclination, β, with the horizontal. There is no nozzle at the discharging extremity. The reservoirs and the pipe being initially full of water, when the pipe is suddenly unstopped the water in it begins to acquire motion of greater and greater velocity, accompanied by progressively increasing friction of the water on the pipe wall and of the particles of water against each other. Finally, after a longer or shorter time, depending on the length of the pipe, the friction becomes sufficiently great to balance the constant action of gravity and the acceleration of the water in the pipe ceases; that is, the mean velocity at any cross-section has now reached a maximum value, V, at which it remains for an indefinite time so long as the positions of the surfaces in the two reservoirs do not appreciably change. In other words, a "state of permanency," or of "steady flow," has now been inaugurated; and it is this kind of flow, of course, that is of much more frequent interest to the engineer than the accelerated flow that precedes it, this latter being what occurs intermittently in the drive-pipe of a hydraulic ram. We are at present concerned only with a "steady flow."

Strictly, the water nearer the axis of the pipe is moving more rapidly than that further away. V represents the average of all these velocities in the same cross-section and is of more importance than the maximum or minimum velocity in the section, since the product of V by the sectional area gives the discharge per unit of time.

If we conceive open piezometers to be set up at different points along the pipe the summits of the stationary water columns in these tubes will define the "Hydraulic Grade Line." For example: If p_a indicates the atmospheric pressure per unit area, and w the weight of a cubic foot of water, the internal fluid pressure at any section, as C, will be $[u\,w + p_a]$ lbs. per sq. ft.

Since the pipe is of uniform bore and the flow steady, it follows that the value of V is the same for all cross-sections and at all times, and hence that the motion of the cylinder of water C M (of length L and diameter D), which is any cylindrical portion of the mass of water in the pipe at a given instant, is uniform. The motion being not only uniform but rectilinear, it results from the laws of mechanics that the total pressure on the rear base C must be equal to the sum of the total pressure on the front base M, and the total friction along the sides of the cylinder C M, together with the component in the direction of the axis of the pipe of the weight of the cylinder of water. This friction may be expressed as the product of F, the friction per unit area (considered constant along the surface), by the area π D L of the curved surface of the cylinder. We have, therefore,

$$\frac{\pi D^2}{4}\left[u\,w + p_a\right] = \frac{\pi D^2}{4}\left[u'\,w + p_a\right] + \pi\,D\,L.\,F + \frac{\pi D^2}{4} L\,w \sin\beta; \qquad (1)$$

that is

$$w\,D\,[u - u' - L \sin\beta\,] = 4\,F\,L. \qquad (2)$$

But $u - u' - L \sin\beta = H$, the "piezometer fall" (see figure); and the ratio $\frac{H}{L}$ may be denoted by a single letter, S, and called the "slope;" (it is to be noted, however, that S is not equal to tan. α unless the pipe is horizontal, nor equal to sin α unless the pipe is parallel to the hydraulic grade line). Hence, finally,

$$4\,F = w\,D\,S. \qquad (3)$$

[It would be nearer the truth if the water between C and M were considered to be made up of a great number of concentric (i.e., co-axial) cylindrical shells, each moving with a (uniform) velocity differing slightly from those of its two neighbors and therefore subject to shearing action (viscosity) from the latter; but it is easily shown that the forces external to this aggregation of shells (since the velocity of each is uniform and rectilinear) bear to each other the same relation (equilibrium) as if acting on a single rigid body having a uniform and rectilinear motion. Hence, eq. (3) would still result from this more refined consideration.]

In the above treatment F has been assumed constant along the pipe. If this is true, it follows that S has the same value all along the pipe, or in other words, that the hydraulic gradient is a straight line for this pipe of uniform bore and uniform character of interior surface; and it also follows that the position of the hydraulic gradient is independent of the inclination of the pipe (for a given length L') and of its depth below the reservoir surfaces, that is, that fluid friction is independent of the pressure in the pipe. Since these results are fairly borne out by experiment it would follow that F is fairly constant along the pipe.

This eq. (3) marks the "parting of the ways," where a fairly rational treatment ceases, further progress depending on the determination (partly by theory and partly by experiment) of F in terms of V, D, and the temperature of the wafer, for a pipe of given character of interior surface (involving some "coefficient of roughness"). Such an expression more or less empirical in its nature, being found for F, and being substituted in eq. (3), we have a relation between V and S, by the combination of which with two other relations, [viz., $H'' = H' + h$, and

$$h = \frac{V^2}{2\,g},$$

(if the inlet of the pipe at E is well rounded; or

$$h = \frac{3}{2} \cdot \frac{V^2}{2\,g},$$

if the inlet is not rounded)] we are enabled to compute V in a given case where H'', L', D, and proper coefficients for the kind of pipe surface, are known.

In many cases, of course, the pipe is so long that h is negligible compared with H'', and S can be considered as equal to H'' ÷ L' without material error.

As to the various values of F under different circumstances, as proposed or inferred, or experimentally determined, by different hydraulicians, a few prominent cases will now be presented.

CASE I.—For very slow velocities and for flow in capillary tubes, it has been found that F may be put equal to $\frac{w\,V}{4\,C\,T\,D}$, in which C is a constant and T a quantity dependent on the temperature of the water. On substitution in eq. (3), there results

$$V = C\,T\,D^2\,S. \qquad (4)$$

CASE II.—For most values of the velocity V in ordinary engineering practice there is more irregularity of motion of the particles among each other, with transverse currents, eddies and impacts, than for the slow velocities of Case I.; and the relation that F is proportional to V^2 is a rude approximation to the truth. If, furthermore, F be regarded as independent of D (a supposition which is wide of the truth) there results $F = C\,V^2$, where C is a constant; and this in eq. (3) gives the old Chézy formula,

$$V = \tfrac{1}{2}\sqrt{\frac{w}{C}}\ \sqrt{D\,S} = C'\sqrt{D\,S}.$$

CASE III.—If F be placed equal to m . w . $\frac{V}{2\,g}$, where m is a quantity dependent both on V and D, and into which the 2 g has been arbitrarily introduced for two reasons (one that $V^2 \div 2\,g$, or velocity-head, is conveniently found from tables; and the other that m thus becomes an abstract number, and is consequently independent of the choice of concrete units) we are led to the relation

$$V = \sqrt{\frac{2\,g}{m}} \cdot \sqrt{\frac{D\,S}{4}}. \qquad (5)$$

In this if we restore the ratio $\frac{H}{L}$ in place of S, there results

$$H = \frac{4\,m\,L}{D} \cdot \frac{V^2}{2\,g}, \qquad (6)$$

giving directly the value of H, or the "friction-head" between C and M. On account of its convenient form, when accompanied by a table of values for m, the expression in (7) is used by several writers on hydraulics, including Mr. Fanning.

CASE IV.—If F be written $= \frac{w\,V^2}{A^2}$, [where A is the well known function of R (= D ÷ 4), S, and a "coefficient of roughness," n, used by Kutter in his formula for the mean velocity of uniform motion in open channels as a multiplier for $\sqrt{\text{hydraulic radius} \times S}$] we have

$$V = \frac{A}{2}\sqrt{D\,S}; \qquad (8)$$

which is used by some engineers for flow in pipes. (See Mr. Trautwine's letter on p. 178 of issue of Sept. 12.)

CASE V.—Again, writing $F = \frac{w}{4\,C^2} \cdot D^{1-2x}\,S^{1-2y}$, where C, x and y are to be determined by experiment, substitution in eq. (3) gives rise to

$$V = C\,D^x\,S^y; \qquad (9)$$

which is the general form proposed by Mr. C. H. Tutton in the "Journal of the Association of Engineering Societies," Vol. XIII., p. 151.

CASE VI.—In Mr. Sullivan's book (referred to above) the claim is made that eq. (3) should read

$$V = C\,D^{\frac{2}{3}}\,S^{\frac{1}{2}}, \qquad (10)$$

for all kinds and sizes of pipes (and also for open channels, replacing D by 4 × hydraulic radius), C varying only with the roughness of pipe wall.

CASE VII.—Manning's Formula.—With the relation

$$F = \frac{w\,V^2\,D}{4\,g\,C^2\left[\frac{\sqrt{D}}{2} + \frac{D}{28} - \frac{1}{20}\right]^2}$$

substituted in eq. (3) we have (and this form only holds for the English foot and second)

$$V = \frac{C\sqrt{g}}{2}\left[1 + \frac{\sqrt{D}}{14} - \frac{1}{10\sqrt{D}}\right]\sqrt{D\,S}. \qquad (11)$$

This is Manning's formula for pipes and is also available for uniform motion in open channels if in place of D there be substituted 4 R, where R is the hydraulic radius of the cross-section. (See p. 161, Vol. 20, of the "Transactions of the Institution of Civil Engineers of Ireland.") C is a coefficient depending only on the roughness of pipe wall, being taken as 15 for old cast-iron pipe and 20 for new (D'Arcy); 29 for new lead pipe, and 31 for glass. This formula is approximately the same as

$$V = C_0\,D^{\frac{2}{3}}\,S^{\frac{1}{2}}, \qquad (12)$$

where C_0 depends only on the nature of pipe wall.

CASE VIII.—The analysis of the French writer, Dupuit, who considered the mass of water in the pipe to consist of concentric cylindrical shells, each moving with a different but uniform velocity and subject to a viscous "friction," or shearing action, from its two neighboring shells, following a special law assumed by that writer (different from those assumed by other French writers using the same method of treatment) leads to the expression

$$F = \frac{w}{4} \cdot \frac{V^2}{C^2\,[C' + D]^2}, \qquad (13)$$

where C and C' are constants for a given kind of pipe. This being substituted in eq. (3) and the values of the constants for cast-iron pipe (clean; D'Arcy's experiments) and for the English foot and second supplied, we have

$$V = 5.34\,[9 + D]\,\sqrt{D\,S}. \qquad (14)$$

Many other formulas could, of course, be quoted but a sufficient number have been dealt with, it is thought,

for the purposes of this communication. It is to be particularly noticed that the relation of V to S, depending as it does, on eq. (3), is purely a matter of the connection between V and F; that is, it depends upon the law of friction, and not upon the law of a falling body $V = \sqrt{2 g h}$.

Sincerely yours,

I. P. Church.

Cornell University, Ithaca, N. Y., Sept. 20, 1901.

Notes and Queries.

In the account of the failure of the concrete-steel vault roof at the Boston City Hall, which was published in our issue of Oct. 17, 1901, an error was made in stating that the concrete was made of Atlas Portland cement. We are informed by the contractors for the work that Lehigh cement was used and not Atlas cement.

NOTES FROM THE ENGINEERING SCHOOLS.

A good illustration of the manner in which the old-established engineering schools are branching out and enlarging their curriculum and course of study comes to us from the Rensselaer Polytechnic Institute. Rensselaer is and always has been a school of civil engineering, yet we are here told that the new electrical laboratory of the school is equipped and in working order. It is equipped with 12 dynamos and motors, and 6 transformers, the latter adapted for two and three-phase working at practically any voltage between 100 and 20,000. We also learn that the new laboratory for testing materials of engineering, including a finely-equipped cement-testing department, is in use this year, and a standard paving-brick testing equipment has just been installed. With such additions to equipment and broadening of the field of work it is not surprising to learn that the Institute opened this year with the largest number of students in the history of the school.

THE WAGER EXPOSURE SCALE FOR TIMING THE EXPOSURE OF PHOTOGRAPHIC NEGATIVES.*

By E. Wager-Smith.

For the beginner in photography, at least, the correct exposure of his negatives is the sine qua non of his success; and even when he understands how to correct the exposure during development, and how to intensify and reduce his negatives after development is completed, he will save himself a great deal of useless drudgery, and will have very much better success if, at the outstart, he correctly exposes his plates.

The question is, therefore, how shall he determine this correct exposure in each individual instance? I venture to say that the inability to answer this seemingly simple question has driven thousands of amateurs from the field, and has caused the expenditure of millions of dollars in ruined material.

Let us consider for a moment the factors which govern the length of an outdoor exposure. We have, in the first place, the month of the year, the hour of the day and the condition of the weather—these three give us the actinic value of the light. Then we have the subject, the size of the diaphragm and the speed of the plate.

There are also two other factors, which have as much bearing on the subject as those mentioned. The first may be expressed by one of the best maxims ever laid down for the guidance of beginners. It reads: "The temperature of the developer is of just as much importance as the length of the exposure." The other factor lies in the fact that the shutters now on the market do not, as a rule, give the lengths of exposure for which they are marked, the one-hundredth of a second (1-100) speed, will usually be found to be between (1-50) one-fiftieth and (1-25) one-twenty-fifth. The best plan, of course, is to get a speed tester and ascertain just what length of exposure the various markings give.

To return to our six main factors—the strength of the sun at different seasons of the year and at different hours of the day may be readily calculated. Rules which have proved to be correct have been laid down regarding the different amounts of time necessary under different conditions of the atmosphere. Laws governing the time necessary for varying subjects have also been formulated. The stop or diaphragm is a simple matter of multiplication and division, and the speeds of different plates is merely a matter of testing.

These different factors were tabulated in book form some time ago, and while serving their purpose to a certain extent, did not allow one to ascertain the correct exposure as swiftly as desirable, did not allow one to check the result, without going through the whole operation a second time and, as the different factors had to be carried in the mind from one page to another, magnified the possibility of an error being made.

Exposure indicators, depending on sensitized paper for their results, have also been used to some extent, but on account of the treacherous nature of this material (for this purpose) have never been favorites with the majority.

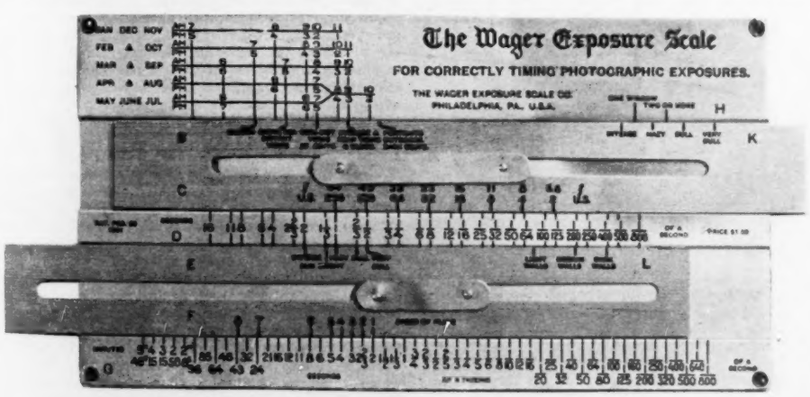
It occurred to me that if an exposure indicator could be devised which would eliminate the undesirable features of the two styles mentioned above, it would be a great help to every amateur in the country. I decided that the then embryotic indicator must embody the following good points: It must be accurate, it must be simple. It must be so arranged that the operator need do no mental arithmetic whatever. It must be so arranged that the result could be checked simultaneously, and its speed of working must be phenomenal. After a long time, I brought it to the desired point, and I think you will find that it has every one of the good qualities I determined it should have at the outstart.

You will notice that the device is composed of three pieces, two of which slide upon the third, and as the best way to show you the working of the invention will be to select a certain set of factors, and see what exposure their combination gives, we will suppose that you wish to take a photograph of a snow scene at 9 a. m. in January.

Selecting the horizontal line for January (at the top of the scale) we follow it with the eye to the point marked 9 a. m. We then move the upper slide until the line for "snow" is immediately below this point, and without further manipulation of the device, find that the exposure with a No. 16 stop is 1-25 second (this being found on the central scale "D," immediately below the "stop" scale "C").

If the sun is intense and fastest plates are being used, we proceed at once to take our picture. But we will suppose that the sun merely casts a faint shadow, and that we are using a "Cramer Slow Iso" plate. We would then move the lower side so that the word "hazy" would come right below 1-25 second (already found) and upon looking below "7" in the "F" scale would see 1 second in the "G" scale. This would be the proper exposure under the six different conditions named. I should say here, that the different standard plates on the market are arranged in numbered groups on the reverse of the scale according to their speed, and that "Cramer Slow Iso" will be found in group No. 7.

I have also added the scales "H," "K" and "L," which, in conjunction with the scales "C" and "F," give the correct exposure for interiors under ordinary conditions.



A SLIDE RULE FOR TIMING PHOTOGRAPHIC EXPOSURES.

*From a paper read before the Franklin Institute, Philadelphia.

THE WORK OF U. S. ENGINEERS IN THE PHILIPPINES is reported upon by Col. J. P. Sanger. The work performed by the officers and the enlisted men of the Engineer Corps, since July, 1898, has generally been the repair and construction of roads, bridges and ferries, mapmaking, the repair and operation of the Dagupan Railway, and the destruction of walls and other defences of the insurgents. Upwards of 8,000 maps have been prepared and distributed, covering sections of the various provinces. They have built and repaired during the last year about 700 miles of road, 278 bridges aggregating 11,146 ft. in length, 268 culverts and 10 ferries. Including work previously done, the total is 939 miles of road and 650 bridges aggregating 13,746 ft. in length. Plans have been prepared for dredging the Pasig River and improving Manila harbor. On July 31, 1901, Maj. Sears was put in charge of Manila harbor and such light-house work as the civil governor may assign to him.

THE TOTAL APPROPRIATIONS for river and harbor work in the United States, to date, amount to $414,765,772, says Congressman Theodoré E. Burton, at the recent river and harbor congress in Baltimore. Down to 1886, the general government appropriated $184,513,339 for the improvement of harbors and rivers, and including 1892, this total amounted to $223,232,432.

THE IMPROVEMENT OF SOUTH AMERICAN WATERways is suggested by Gen. Rafael Reyes, Vice-President of Colombia, Minister to France of that country, and now a delegate to the Pan-American Exposition. He proposes to present to the United States Congress a plan uniting by great waterways all the countries of South America except Chili. He asserts that the building of a short canal through the Sierra Eselavana will unite the headwaters of the Parana, emptying into the Rio de la Plata, and the Tocantin, flowing into the Amazon; and tributaries of these two great rivers—which can be made navigable, extend from the most westerly point of Peru to the coast of Brazil, and from Colombia south to Argentina and Uruguay. He argues that the territory thus opened is filled with forests of rare woods, india rubber, cocoa, etc., now unavailable owing to lack of transportation. Gen. Reyes does not explain the direct interest of the United States in this proposed improvement.

A NEW HARBOR AT DOVER, ENGLAND, is now under construction, but will not be completed before 1907. The Prince of Wales or East Pier has been carried out from shore 1,260 ft. by an iron viaduct and 1,650 ft. by solid masonry. This work will be finished in about two years, and will then provide a landing stage for three or four of the largest Atlantic liners; and the German ships will then make this a port of call. To complete the harbor a south breakwater will be built in front of the harbor, and the entrance to the inshore docks will be rearranged and a great station built to accommodate the channel traffic. The present tidal harbor will be converted into a wet-dock, opening into the Granville and Wellington docks by a lock 450 ft. long. When completed the harbor will be closed in, with two entrances, one to the south and the other to the east.

A "STATE COMMERCE CONVENTION" was held at Buffalo, N. Y., on Oct. 16 and 17, at which the principal topic of discussion was the improvement of the New York canals. Delegates from Rochester favored the construction by the National Government of a ship canal from the Great Lakes to the Hudson, but those who favored the construction by the State of a 1,000-ton barge canal were successful in obtaining a nearly unanimous vote in favor of that project.

THE CAPE COD CANAL SURVEY is nearly completed—in its field work—in accordance with the act of the last Massachusetts legislature. The work is being done under the Harbor and Land Commission, of which Mr. F. W. Hodgdon, M. Am. Soc. C. E., is Chief Engineer; Mr. Henry B. Wood, M. Am. Soc. C. E., is in charge of the surveys. The survey of the Taunton River, below Taunton, is not yet completed, says the Boston "Transcript," The report to the legislature, including the full survey and estimates of cost, is due on Jan. 15, 1902, and for this work $10,000 was appropriated. As far as published, the surveys call for excavation and dredging for a length of about 45 miles. An elevation of 140 ft. above tide is reached between Avon and Brockton; and as the canal is to be 26 ft. deep, locks will be required. The "Transcript" says that it has no evidence that any organization is anxious to build the canal when the surveys are completed.

A SHOSHONE RIVER IRRIGATION AND POWER scheme is under consideration by Col. Wm. F. Cody and Nate Salisbury. The plans call for a power plant on the river near Cody City, Wyo., and the object is to reclaim 150,000 acres of land at a cost of about $800,000. The canal would be about 30 miles long, 35 ft. wide and 7 ft. deep; with a masonry dam across the river above Cody City. A branch canal—2 miles long—would irrigate a tract of 15,000 acres near the town.

THE BIDS FOR PAVING AND SEWERAGE WORK in Havana, Cuba, on Oct. 23, ranged from $10,393,016 to $11,485,896. The lowest bid was submitted by Messrs. A. P. McGivney and R. T. Rockeby, of Jersey City, and the highest by the Pan-American Construction Co., or Michael J. Dady, of Brooklyn, N. Y., and others.

THE REDRIDGE DAM, built by the Atlantic Mining Co., at Redridge, Mich., and illustrated and described in our issue of Aug. 15, was put into service Oct. 28. The dam was built under direction of Mr. Foster Crowell, M. Am. Soc. C. E., of New York city.

PLUMB-LINES 4,250 FT. LONG were lately swung in Shaft No. 5 of the Tamarack copper mine in the Lake Superior copper regions. It was desired to cross-cut at the 29th level, or a point 4,250 ft. below the surface, and two plumb-lines were dropped to give the direction. No. 24 piano-wire was used, and these wires were lowered from drums attached to a small two-cylinder hoisting engine placed at the mouth of the shaft. To carry the wires down and prevent entanglement in the timbers two "balloons" were used. These were made of wood, were 10 ft. long, 2½ feet diameter at the center and tapered to a point at both ends, and weighed 20 lbs. each. A lantern was swung in the center of each balloon. The lines were dropped to the bottom in 30 minutes, and 8-lb. plumb-bobs were substituted for the wooden ones until the wires were adjusted for distance. Then 50-lb. bobs were attached and the wires stretched 15 ft., requiring that much to be cut off of each. When all was ready the bobs were immersed in two pails of engine oil, to check vibrations; but here something unlooked for occurred, as the wires shortened up 25 ins. because of the buoyancy of the oil. A similar set of plumb-lines was swung in Shaft No. 2, 3,220 ft. distant from No. 5, at the surface. In both cases a divergence of about 1-10 ft. was noted in the distance of the wires from each other; at the top of the shaft this distance was 12.6 ft., and it was 12.7 ft. at a point 4,250 ft. down. Lead bobs were tried instead of the iron ones, but without changing the result. No explanation is given for the disturbing force in the account so far published.

THE CABLE-MAKING MACHINERY for the new East River Bridge, in New York, is almost in place and work upon the cable will commence in a few days. One of the guide-wires—a ⅝-in. steel rope—is now in position and adjusted.

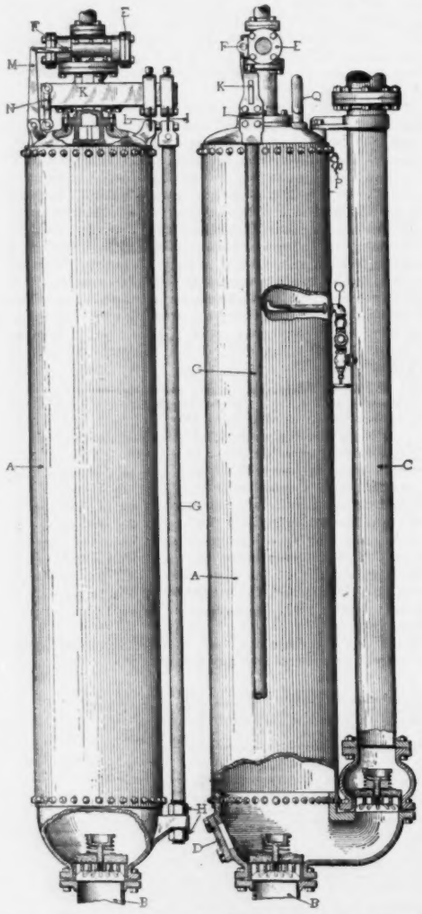
A 4,000,000 CU. FT. GAS-HOLDER has been erected in St. Louis by the Laclede Gas Light Co. As described in the St. Louis "Republic," this holder is 150 ft. high, and 210 ft. in diameter, telescoping in four sections. The construction of the tank alone cost $250,000, and it was made by the Riter-Conley Co., of Pittsburg, Pa. The Chief Engineer of the gas company is Mr. Byron E. Chollar.

THE SEATTLE FLOATING DRY-DOCK, or the first section of it, was launched lately from the shipyards of the Moran Bros., of that city. This dock, when finished, will be 200 ft. long and 80 ft. wide; the pontoon is 12 ft. deep and the towers 30 ft. high; the displacement is 2,000 tons and the lifting capacity 3,000 tons. This dock is so constructed that it may be used in conjunction with another of like dimensions now under construction, and the two will readily lift the largest ship in Pacific waters.

A NEW STEAM VACUUM PUMP WITH POSITIVE VALVE MOTION.

A novel application of well-known principles is made use of in a steam pump recently designed. The apparatus is intended for use in contract and construction work requiring the handling of water, in mines, quarries, and isolated works of all kinds. A number of conditions were required to be satisfied; the water carrying silt or sand must be handled as readily as clear water; the operation must be undisturbed by even large quantities of air in the suction; the pump must be light, easily handled and moved, preferably with flexible connection to the steam supply; must be self-contained, requiring no fixed or firm base; must be simple in construction, self-regulating if the supply ceases, and finally must be fairly economical in the use of steam. The makers claim complete success in attaining all these aims.

The construction of the pump is clearly shown in the figure. A cylindrical steel receiving tank A has a valve chamber attached at its lower end with connections B and C for suction and delivery pipes. At its upper end the casing of the steam valve is attached. When this valve admits steam to the tank, any water, etc., contained in the latter is forced out through the delivery pipe C. If steam is now shut off, the vacuum forming in the receiver draws water in through the suction valve at B. In these particulars of its operation this pump is very similar to other steam vacuum pumps. The method of controlling steam supply, however, differs radically from any used heretofore. The steam valve E is of the piston type, controlling steam admission through a double-ported seat of ample capacity. This valve is operated by steam from the main steam pipe admitted at one end or the other of the main valve chamber by the little auxiliary piston valve F. This latter valve, through a system of multiplying levers, is operated by a steel rod G, fixed at its lower end to the water-valve chamber at the bottom of the receiver, and engaging the multiplying levers at its upper end. Any movement of this rod up or down moves the valve F, which in turn throws valve E. The motion of rod G is produced by the expansion and contraction of the tank body A, under the influence of either steam or water. If the heat of the steam causes the tank to expand and elongate, the downward



Front and Side Views, Partly in Section, of Steam Vacuum Pump.

Emerson Pump Co., Washington, D. C., Manufacturers.

movement of rod G, through its effect on the valves, shuts off the steam supply. As the steam begins to condense, it draws water up through B, condenses then more rapidly till tank A is full of water, whereupon the cooling of the tank again admits steam.

Further points of construction are: a small pipe connection at O, with hand and check valve, which admits a small spray of water to the steam tank at the beginning of the suction in order to more rapidly condense the steam; handhole covers, as shown at D, to give access to the water valves; an eyebolt at Q, by which to suspend the pump.

The basis of construction of this pump, and at the same time its main novelty, is the method of operating the steam valve. But the consequent great simplicity attained, the small weight, compact form and general adaptability are valuable features in themselves.

The pump is made in a number of sizes of a capacity from 100 to 1,000 gallons per minute at 100-ft. lift; the corresponding diameters of tank are 6 and 24-in. The Emerson Pump Co., Mertz Bldg., Washington, D. C., are the manufacturers.

THE ROTARY KILN PROCESS OF CEMENT MANUFACTURE.*

(Concluded from page 320.)

ORAL DISCUSSION.

Mr. V. de Michele wished to ask how long the clinker lining of the burning cylinder lasted. The lining of a kiln was one of the most costly items in cement manufacture, and it would be valuable if the authors could say what was the duration of the linings. With regard to the mechanical difficulty of lengthening the burning cylinder, according to the diagrams it appeared that the cylinders were supported at two points, and he would like to know whether there was any difficulty in increasing the number of those supports to three or more. If there were no difficulty in doing so, he did not see why it should be more difficult to construct a cylinder 100 ft. long than one 60 ft. long. It seemed from the results in the paper that with the wet process 100 ft. was nearer the correct length than 60 ft.

Mr. L. B. Atkinson remarked that there were a few points to which he would like to draw special attention, and among these the use of wet slurry appeared to him to be one of the most important matters for the cement manufacturers of this country to thoroughly consider. Assuming the authors' calculations to be correct, it appeared that a very large portion of the heat required was taken up in evaporating water which, if the authors were correct in their idea that the mixing might be done dry, was unnecessary. He had visited the Atlas Cement Works last autumn, and at the time of his visit there had been over fifty kilns in work, and another fifty in an advanced stage of construction. About 1,500 tons of finished cement were being turned out daily, and with some little experience of manufacturing concerns he had been very much struck with the organization and the ability which had been shown in maintaining a regular output with all the various processes, which were necessarily dovetailed one into another. One of the points that would strike an engineer as being most novel and important was the use of powdered fuel. He had seen in Europe certain experiments with powdered fuel before, but it had been quite a revelation to him to see 500 tons or 600 tons of fuel burnt per day, apparently without any stoking whatever. The coal being dried and ground in the mills, the fuel was carried automatically into the stock box, and the stoking consisted in simply adjusting the valves of the air supply regulating the amount of fuel going into the furnaces. The success of the particular burners used was due to several causes. The first was the appreciation of the fact that the feed of coal must be a positive feed; there were screw gears driven by small engines which could be regulated in speed, so that the actual amount of fuel fed forward was well under control. The coal dust was then mixed with air, so as to produce what he might call an emulsion of coal and air, and was then blown into the furnace with a small quantity of high-pressure air. There was a point about that high-pressure air which was of importance, namely, that in addition to blowing the fuel in the direction of the length of the kiln, the air expanded, and blew the fuel to the periphery of the kiln. All the fan-driven coal-consuming devices he had seen had the disadvantage that they projected a stream of coal along the axis of the kiln, but it did not reach the periphery where the heat was required, with the result that in many powdered-coal-burning devices working on rotary kilns of that kind a very large amount of fuel was blown straight through the kiln and up the chimney, and was not burned in the furnace. He did not think that anything save high-pressure steam or air, expanding laterally as well as longitudinally, would achieve the result that was obtained. The temperatures that could be obtained with such a blast were surprising, and he thought he was well within the mark in saying that the difficulty in watching the furnace was to avoid melting out the whole of the firebrick in a fluid condition. There seemed to be no practical limit to the temperature which could be obtained. The authors described the clinker lining in the furnace as being fixed by coating the internal surface of the kiln with common salt, forming a fluxed or glazed surface to which the clinker adhered. But the practice as carried out when he had seen it had gone a stage further. As the clinker came down, while the lining was being formed, salt was placed not only on the lining of the furnace, but on the clinker, which had to be beaten down. The following was probably the explanation of the result: Even if the temperature of the furnace were raised high enough to somewhat soften the interior lining, when the clinker was brought down on it the result was the formation of a lime glass at the union of the two surfaces, and a lime glass, speaking generally, was of a very fluid nature when it was formed. The introduction of the salt both at the lining and into the body of the clinker formed a soda-lime glass, which

*Abstracted from a paper by Wm. Harry Stanger and Bertram Blount, read before the Institution of Civil Engineers.

was of a very much more plastic nature, and the result of that was twofold. There was really more adhesion between the clinker and the brick lining, but in addition, by getting a lining in that plastic condition and then beating it down, a circular arch was formed which, mechanically and quite apart from the adhesion, was complete in itself, and would hold in position. That process was in a sense equivalent to forming in place an interior lining of clinker, built into a circular arch. A previous speaker had asked what was the life of such a lining. Some of the kilns which he had seen had been running for two years, and had had no repairs whatever to the brick lining behind the clinker lining. A certain amount of repair was done from day to day in small patches on the clinker lining, but that was effected as the work proceeded by stopping in not a convenient material of which to make bricks by the plant for a short time.

The plastic clinker was beaten down by means of a bar about 20 ft. long, with a heavy iron weight at the end of it—something like a puddling bar—which was worked up and down through an opening by the operator outside. Only patches of about 2 sq. yds. were done at a time. When the furnace was new it might take four days to complete the fixing of the lining, and then the kiln was ready for work. One of the reasons for the success of the plant was, he thought, that great care was taken in constantly checking the material put into the kiln. It was quite obvious that in a plant turning out 1,500 tons a day, and which would shortly be dealing with double that quantity, if care were not taken when the material went into the works from the quarry, a very large amount of useless cement might be produced. Samples were taken every half-hour from the actual mixture leaving the grinding mills. It was found that as work was carried from one part of the quarry to the other the variations, though not rapid, could be detected. Only the lime was determined, and the mixture was checked in that way to enable the proportion of lime to be maintained uniform. Experience showed that quite a small alteration in the quantity of lime, say, ¼ to ½%, whether too high or too low, might give rise to difficulty in working the kilns. It was a vital point in the process to exercise care in regard to the mixture put into the kilns, for an improper mixture of raw material produced an unsatisfactory product. Much thought and intelligence had evidently been brought to bear on the design of the plant, but with some little knowledge of grinding machinery he thought that if anything had to be altered it would be the grinding plant. The fact that one grinding machine had been chosen to grind a soft substance like coal and hard stuff like cement clinker was sufficient, to his mind, to show that convenience rather than real efficiency of the grinding plant had been the object aimed at. The amount of power used for grinding appeared to be excessive; roughly speaking, even on the newer plant it was 80 HP. per ton of cement produced per day, which was a very large amount. The new plant was of 12,000 HP., of which quite a large part was occupied solely in grinding. The grinding, whether of coal, raw materials or cement clinker, was done in one stage, that was, the stuff was put into the grinding mills about the size of walnuts, and on coming out had to pass through a 100 × 100-mesh sieve. He believed Mr. Hurry himself thought that a great economy of power might be arrived at by doing the grinding in two stages. Economy in power was much more important in this country than in America, because coal was very much cheaper there. His criticism, however, was not founded on any experience with that particular plant, but on some experience of grinding machinery in general. Referring again to the question of wet slurry and of lengthening the kilns, the point arose whether a kiln of that kind was a proper place in which to evaporate moist slurry. It was well known that if coal were burnt in the flue of a Lancashire boiler and the hot gases went out at the end, there was considerable waste of heat. It was necessary to pass the hot gases through an economizer in order really to get the heat out of them. If it were found that wet materials must be used, he thought something would have to be done in the way of pumping the materials through what was equivalent to an economizer, without attempting to dispel the moisture simply in one long flue through which the gases were passing at a very high velocity, which was a very useful arrangement where radiant heat was available, but a poor arrangement for getting the heat out of non-radiant gases.

Mr. Gilbert R. Redgrave remarked that the question of burning Portland cement had undergone a wonderful change in the past few years. He had seen, some 10 years or 12 years ago, at the works of the South Wales Portland Cement Co., one of the early cylinders used for cement burning in this country. He had watched the work for some time, and the process had given him the impression that it was bound to be a failure. The difficulties in connection with the use of the cylinder were at that time enormous. The clinker was constantly fusing into large masses in the interior, causing great labor in the removal of the semi-fused mass and frequent interruption of the work. Moreover, in order to produce the cement in the cylinders, it was found necessary to employ a high percentage of lime, a fact which had not come out previously. He had found, on analysis, that the cement thus produced in South Wales had contained 64% of lime, and it had therefore been a treacherous material. The temperature of burning had been very high, and the question of temperature was a very important one. In the early days of cylinders for cement manufacture it had been customary to use gaseous fuel, and he believed the salvation of the burning cylinder was due to the present use of powdered coal fuel or oil fuel. The temperature attained with producer gas had been excessive; and the enormous heat produced in one part of the cylinder had tended to fuse, not only the linings, but also the cement in course of manufacture. One of the most interesting matters described in the paper was the method of lining the tube and the protective influence of the clinker. No cement manufacturer who had watched the burning in the ordinary firebrick kiln could fail to be impressed with the wastefulness of the present process. Without the utmost care, the destruction of the linings was very rapid, partly on account of the difficulty of regulating the draft in the kiln. Cement makers had constantly to face the question of relining kilns. If by the process which had been described it was possible to make a protective lining for a kiln, or a burning cylinder which would last for two years, an enormous advance was secured. Another matter which deserved great attention was the distribution of the heat in the cylinder, not merely caused by the powdered fuel, but influenced also by the action of the compressed air brought in with it. The expansion which took place in the jet at the entrance to the cylinder caused the heat to be distributed all over the tube lining. He was rather doubtful of the effect of a great length of cylinder. He had no practical experience of what was being done in America, but looking at the fact that English cement manufacturers, at any rate on the Thames and Medway, produced cement very largely from a mixture of chalk and clay, in a semi-liquid form, it seemed doubtful whether the best method was that of introducing the mixture into the long cylinder in which it would gradually become heated. He thought it might be preferable to dry the mixture by some other means rather than in the cylinder itself, but that was a matter to be decided by experience. It was interesting to know that the Associated Portland Cement Manufacturers had set themselves earnestly to work to carry out improvements in the process of manufacture. It was a question whether it would not be necessary in the near future for English cement manufacturers to face this matter very seriously indeed. The existing works were antiquated, and if it was possible by improved methods to effect a saving of 5s. a ton, it would be almost imperative to remodel them forthwith. It was not only in the matter of burning that he thought the cylinder process had a great future; there was also the question of the grinding. For years past engineers had been urging the necessity for fine cement, but English manufacturers had never really grappled seriously with the problem. Abroad and in America great attention was paid to reducing the cement to the finest possible state of subdivision. The present plan, which obtained very largely in this country, of grinding by means of millstones, was an unsatisfactory method of attaining anything like the necessary degree of fineness. In the tube mills it was possible at a small cost to reduce cement to a very fine state of subdivision. Before long cement users would not care to employ Portland cement which had not been ground to a degree of fineness hitherto undreamt of. The common specifications of engineers in this country required not more than some small percentage of residue on a 50-mesh sieve, that was, 2,500 meshes to the square inch; but the residue even on a 100-mesh sieve was of little or no use for engineering purposes, and therefore manufacturers must look to the time when specifications would require them to produce extremely finely ground material. Not only in burning, but also in grinding cement, processes which were practically novel to the English cement manufacturer would be employed in the future. It would be useful to obtain from the authors, or from others, the results of experience of the use of an iron lining in the kiln. In some of the recent processes of burning an unprotected iron cylinder was used, and it was stated that by distributing the air supply to the kiln over the surface of the metal cylinder, which was used vertically, it was possible to burn Portland cement without any firebrick lining at all. That seemed to be a direction in which cement makers might attempt to get over the difficulties of the fusion of the firebrick linings. There were vertical iron kilns which had no protective lining whatever; an excellent cement was said to be produced in such kilns, and by that means contamination of the cement with the products arising from the fusion and destruction of the kiln-linings was avoided. It was a pleasure to find that the experience which had been so rapidly gained in America was to be brought to bear in England, and he trusted that the experiment now being made by the Association of Portland Cement Manufacturers would be crowned with success.

Mr. William Gilbert said the Schneider kiln was one of the most modern of fixed continuous kilns, and merited further description. He had visited cement works in Germany and Sweden during the last two years, and was able to say that the Schneider kiln was an exceedingly satisfactory one. It was a vertical kiln, being practically a plain cylindrical shaft surmounted by a chimney, and it fulfilled the authors' requirements for an economical kiln. The ingoing air cooled the outgoing clinker, and the furnace gases were used to heat the raw materials. Further, the tendency of the plastic clinker to adhere to the sides of the kiln had been overcome in a very simple manner. At the Limhamn Cement Works, in Sweden, the damp bricks of raw maetrial were loaded directly into the top of the kiln, and the consumption of coke amounted to 3¾ cwt. per ton of cement, or 19% of the weight of the clinker produced, which compared very favorably with the 30% of small coal used in the rotary furnace. The first cost of the two fuels would, however, be about the same. Using the rotary kiln, the labor of loading and withdrawing the clinker was almost obviated; but in the case of the bottle kiln the charge for both those items, including picking the clinker and digging the slurry from the drying floors, was only 1s. 9d. per ton; so that really the saving in labor was not great. For a given output, taking the coal grinding plant into consideration, the cost of a rotary plant would be much greater than that of a Schneider kiln plant. The rotary kiln appeared to work very successfully in America, where the dry process was used; but in England, where the wet process was almost universal, and necessarily so, it had not yet been a success. It therefore seemed a little premature to recommend cement manufactured by it to members of the institution.

Mr. W. L. H. Roberts remarked that, not having had the advantage of seeing a rotary kiln plant at work, the paper had set his mind very much at rest at to what was going on in America. The authors stated that Portland cement, of better and more regular quality than at present produced, could be made by the plant; but he fancied that if engineers in this country were led to believe that the cement which was going to be produced in rotary kilns was far superior to that produced now, it would rather injure the position of English manufacturers. With regard to the tests of the cement manufactured by the Atlas Co., it would be noticed that it was particularly slow-setting, and that the results were not any better than would be produced by a slow-setting cement manufactured in a properly-regulated English cement works. If the statements in the paper were taken simply as they stood, engineers as a body might possibly be led into thinking that the rotary principle was going to p oduce a better cement than that which could be made by fixed kilns. The Schneider kiln was an excellent one, well adapted to a great number of raw materials found in this country, and he believed that the cost of a properly-regulated works using the Schneider plant, or other kiln such as was being used in this country, would compare very favorably with that of rotary kilns. The bugbear of picking out the underburnt particles was not very great; they could be easily picked out, especially if, as was usual, the older men were employed to do it. If an ordinary picking table was introduced as well, the trouble arising from under-burnt clinker entirely disappeared. With regard to artificially-matured cement, no doubt it was excellent, but at the same time in this country the cement had been matured by having very large warehouses in which to keep fairly large stocks, and in the summer time, when the cement was apt to set quickly, it had been the practice of many manufacturers to water the clinker. Watering the clinker was an ordinary process, and the advantage was all on the side of the manufacturer, because the cement gained about 2% in weight, and he therefore pocketed an extra 2%, which purely from the manufacturer's point of view was a satisfactory result. He did not think, however, it should be allowed to go forth that it was anything new, as it had been known and practiced for years. The rotary process might suit certain manufacturers, but even without that plant British manufacturers could produce cement just as good as, and in a great number of cases far better than, any produced by the employment of the rotary principle.

Mr. R. E. Ellis said that no reference had been made by the authors or by any of the speakers to Messrs. Hurry and Seaman's recent expriments. Instead of burning the cement materials to a semi-vitreous clinker, they partially calcined them and then submitted them to a temperature capable of producing complete fusion, and when solidified, powdered the product thus obtained. Though experts had differed from them in regard to that process, their experience was that when the constituents of the raw material were properly proportioned, the cement produced by the fusion was superior in its qualities to that manufactured by other methods.

Mr. W. F. Reid did not wish in any way to minimize the credit due to Messrs. Hurry and Seaman, but the conditions under which the furnaces were used in America were very different from those obtaining on the Thames and Medway. The materials mentioned by the authors were materials already partially mixed in a natural state, and that natural mixture was much finer and more intimate than could be obtained in a mechanical mixture. Judging from the figures in the paper, about half the carbonate of lime was already in a state of intimate admixture with the argillaceous constituents, and under those circumstances it was not only easier to burn the cement, but it took less fuel, and there was much less chance of any mishap during the burning. He had found, many years before, in establishing the cement industry in the Rugby district, where the lias materials were used, that it required much less fuel and much less careful regulation of the heat in the kiln, when making cement from lias materials than when using a mechanical mixture of

chalk and clay; and manufacturers would find it much more difficult to burn a mixture of chalk and clay, such as was used in the neighborhood of London, than material which was already intimately mixed. He would not say, however, that the difficulty might not be overcome. With regard to fuel, that was a very important matter for cement manufacturers, not only in the London district, but throughout the country. It had been suggested many years ago—and the suggestion had been tried on a large scale—that the powdered fuel should be mixed with the slurry. He had made a number of experiments upon that, and had found that when the mixed materials were in masses of considerable size, it was quite hopeless to attempt to burn them by means of powdered fuel mixed with them; but when, on the other hand, the material was subdivided into small particles about the size of hazel nuts, the combustion was perfect. If part of the fuel was mixed in a finely-powdered state with the raw materials, the burning would be much more uniform, and possibly the lining of the kiln would be less affected. The lining was a very important item in the expenditure of cement works, not only for materials, but also for labor and on account of the cessation of work involved by its renewal. The method adopted by Messrs. Hurry and Seaman was highly ingenious, and would mark a great advance in the manufacture of Portland cement if it turned out as well in England as it seemed to have turned out in the United States. At the same time he was not quite sure that the materials used in this country would act in the same way as those employed in America. Many years ago it had been a constant practice among manufacturers to plaster the inside of their kilns with the slurry, which, to a large extent, protected the bricks. Another way of preventing the wearing of the lining of the kiln was by means of a water jacket, a method which had been used a great deal in puddling furnaces. It was possible to fuse metal in a naked steel cylinder very easily if there was sufficient cooling water outside. He had had occasion to employ this method himself in a place where firebricks cost about 6d. each, and where he had had to use very inferior material; he had put a water jacket outside, and it had stood very well. Although the corrosion of the lining in rotary kilns might be considerable, and the consequent repairs numerous and frequent, under the wear and tear of the furnaces, yet it was not out of proportion to the output.

Mr. D. B. Butler thought it was time English manufacturers found some more economical method of burning cement than that mainly in use at the present time. It was obvious that an immense amount of heat was wasted in the alternate heating and cooling of the ordinary type of intermittent kiln, such as was shown in Fig. 1, which, together with the drying chamber, contained something like 12,000 cu. ft. of brickwork, and had to be cooled down after every burning sufficiently for men to get inside to reload it. He could not quite agree with the authors that the limitation of the percentage of lime was due to irregular burning, because he thought bad mixing of raw materials had a great deal to do with it. In cement manufacture there were three distinct operations: (1) the intimate mechanical mixture of the raw materials; (2) the burning of those raw materials when they were mixed to make them combine chemically; and (3) the grinding of the clinker to enable it to combine with water and to set. The authors stated that some form of continuous kiln was generally employed for burning raw materials treated by the dry process, but he did not think that applied to England. The Dietsch kiln had been tried in some places with very indifferent results. The theoretical calculations as to the amount of fuel required to burn cement were interesting, but there appeared to be too many assumptions to make them conclusive. For instance, 20% was allowed for radiation, and so on. The authors were rather hard on English manufacturers for using the wet process, but he thought a good deal was to be said for it. The chalk going to the wash mill contained about 20% of water, and the clay about 45%. These materials being mixed in the ratio of about 2 of chalk to 1 of clay would give about 28% of water in the mixed material, or only about 12% of added water to be evaporated, since the slurry contained about 40%. The cost of evaporating this small amount of added water would be fully compensated by the more ready and efficient mixture obtained by the wash mill. Another important point in favor of the wet process was that the flints in the chalk would be practically irreducible by the ordinary method of grinding, and if the dry process were used they would require to be eliminated in the first instance by washing or by some other method entailing extra expense. The authors appeared to attach considerable importance to the watering of the clinker and its effect on the cement. He doubted very much whether the 2% of water shown by the analysis penetrated sufficiently within the internal portions of the clinker to make it efficient. The tests of the cement were put forward as indicating rather a superior quality; but judging from numerous samples which daily passed through his hands for testing purposes, all first-class brands of European cement made by the ordinary process were quite equal to that mentioned in the paper. With regard to cost, the only difference in labor between the rotary process and the ordinary intermittent process was in the loading and drawing of the kilns. The cost of labor given in the paper was 2s. per ton of cement by the rotary process, and 4s. 9d. per ton by the ordinary process, which left a difference of 2s. 9d. per ton; but his experience was that the dried slurry could be loaded into the kilns and the clinker drawn to the crushers for about 1s. 6d. a ton inclusive, suggesting that the authors' figures in favor of the process were a little optimistic.

Mr. J. F. Plaister said the authors seemed to make a great point of the automatic manner in which Messrs. Hurry and Seaman handled the materials, as if it was peculiar to their works, but other works in America handled their materials equally well and had their kilns working with equally good results. He had also had an opportunity of examining the books of one of the oldest cement companies in America, and he had been able to compare in respect of cost of production the old-fashioned method of bottle kilns and millstones, with the continental method of a continuous coal kiln known as the Schaffer kiln, which had been running in Denmark for some years, and with the rotary process, the grinding in the two latter systems being done with ball and tube mills. He had come to the conclusion that there was absolutely no economy in the rotary process, but certainly a great improvement in the methods of burning, the cost of manufacture with the Schaffer kiln being practically the same as with the rotary kiln.

He could not quite agree with the figures the authors gave as to the cost of manufacture of cement in America. He was afraid manufacturers would not stand much chance in England if the Americans progressed at that rate. He had found in the United States that the general estimate of the cost of manufacture of cement at the present time was £1 per ton by the dry process with rotary kilns. Messrs. Hurry and Seaman might have some extraordinary method which made a great difference, but he knew from the books of the company he had referred to, and also from experts he had met in New York and Philadelphia, that that had been the cost last year, taking coal at 8s. per ton. Therefore, unless great economy was going to be effected in other ways, he did not think any saving was to be looked for from the adoption of the rotary plant; but no doubt a much better cement would be produced.

The results given by the authors had probably been taken from the Atlas Company's cement of 1898, but that cement was much inferior to the American cement of 1900. He had seen test pieces withstand a tensile stress of 1,500 lbs. per sq. in., neat, after 3 months. He had gone through the test books for 4 years of one of the oldest cement works, and had found equal results. The sand tests showed 370 lbs. at 7 days, and something like 450 lbs. at 28 days. That, he thought, proved the high quality of the cement that was being made. The standard fineness in America at the present time was 95% to pass through a 100-mesh sieve.

He noticed that the authors, in their estimate of cost, took the raw materials delivered to the mill at 1s. 9¾d. per ton of cement. He did not know how they did that at the Atlas works, because in 1898 he believed they had to buy considerable quantities of limestone, and the stone obtained from their own quarries was conveyed by carts to where it was used. No allowance was made for drying the coal, although that was a very important item. Also no allowance was made for drying the raw material, the cost of which surely could not be included in the 1s. 9¾d. per ton. With regard to repairs, his experience was that their cost was a most difficult item to arrive at. The labor seemed to be about right, as the cost of ordinary unskilled labor in Pennsylvania at the present time was 6d. an hour and for enginemen 10s. a day. Labor was exceptionally cheap in the Pennsylvania district.

He had seen the Dietsch method of working on the Continent, and considered it an economical one, but the difficulty in England was that the labor could not be obtained to cope with it. He had been working the Schneider kiln for the past 12 months, and that was undoubtedly a most economical method for English manufacturers, used in conjunction with drying floors. By putting additional floors in the existing chamber kilns any manufacturer could dry a sufficient quantity of slurry to keep Schneider kilns going without additional fuel, and with no wear and tear except on the floor itself. In the Schneider kiln it was possible to burn a first-class clinker with 3 cwt. of extra coke per ton of cement. That had been promised him when he was first shown the kiln in Germany, and since then he had proved by practical experience that this result was easily obtainable.

With regard to the difficult classes of rotary kilns, he had seen plain cylinder kilns, of various lengths up to 90 ft., working successfully. At one works he had seen one 40-ft., one 60-ft. and one 90-ft. cylinder, alongside one another, and the manager had been of opinion that an ideal kiln for the dry process was one 60 ft. in length. He thought a longer kiln would be found necessary for the wet process. Two kilns he was erecting at present were only 60 ft. long, but he had not known three years ago as much as he knew now.

With regard to cooling it was stated in the paper that Messrs. Hurry and Seaman were the only makers who dealt with the cooling of the clinker methodically. The general system of cooling in America was by means of a cooling tower, a large cylinder about 32 ft. in height and 8 ft. in diameter having a large cast-iron pipe leading up the center, with openings at intervals, and baffle-plates inside the tower. A large fan forced air through the cylinder, and the clinker was put in at the top and dropped out at the bottom on to a band conveyor, which took it direct to the mills. In one works he had visited, the raw material was taken from the rock by trucks to the crusher, and from there it was never touched by hand until it was loaded in casks into the trucks. None of the works he had visited used anything but powdered coal; oil had been abandoned at most works in America for some time past. Coal was found, and he thought would be found, the most economical fuel for burning.

Mr. Leedham White found himself in almost complete agreement with the facts brought forward, and with the deductions made in the paper. Two years ago he had been one of a commission of four who had gone to America for the express purpose of studying the rotary kiln. The commission had first proceeded to Michigan, and had seen the works described in the paper and other works. At those works they had seen the burning conducted entirely by means of oil fuel, and the manufacture carried on by the wet process only. The commission had visited those works in order to satisfy themselves that the system of burning by the rotary kiln could be effectually employed with the wet process. They had seen the process efficiently applied to wet slurry, exactly analogous in chemical composition to the materials which were used on the Thames and Medway, and they had seen made by the wet process some of the finest cement they had ever met with.

A prolonged visit had then been paid to the Atlas Works, which had been inspected very carefully. The commission had seen the dry material most successfully treated and the burning carried on by coal exactly as was described in the paper. It did not require a very great act of faith to combine the two experiences, and to assume that the wet process could be successfully applied in England, and that combustion could be successfully carried on by coal instead of oil. The result had been that the commission had unanimously recommended their company to take up the system of rotary kilns, which the company had done, and a very large plant, strictly modelled on the Atlas system, was now on the eve of being completed. So far from the rotary principle not being well adapted to the wet process, some of the very best cement he had ever seen had been made by the wet process in rotary kilns. There was indeed one reason why that cement should be slightly better than cement made by the dry process. For some reason or other, probably because in the process of gradually drying from a thick liquid into mud, and the slow consolidation of the mud into harder lumps, the lumps were, from the beginning, so small that the clinker came out in hard, burnt, dense pieces literally about the size of filberts. He defied anyone to find finer clinker than that he had seen produced by the wet process combined with the rotary system.

He did not suppose absolute finality had been reached with the present description of kiln, and certain improvements might yet have to be introduced, and certain problems settled. The length, diameter, and internal shape of the cylinder, even, perhaps, the exact incline at which it was set, were all matters to be gradually thrashed out, but no doubt after a time a decision would be arrived at as to what was the most suitable cylinder for the process. Of one thing the members might be assured, namely, that the rotary principle would endure, and it would be a long time before it was superseded by something better. It was perfectly true that it produced cement of a somewhat better character, but at the same time it was not necessary to decry too much the present system of manufacture. The adoption of the rotary system would enable the manufacturer, with greater ease, to produce a regularity of quality which was somewhat difficult to obtain with present processes.

The President remarked that there was one important point in the paper to which he wished to refer, and that was the claim for the process of getting straight from the works cement which was perfectly mature. Engineers who had to deal with large quantities of cement incurred very great expense in providing cooling sheds; and he had found, after handling about 50,000 tons in one place, that the cost of the construction of those sheds and the labor came to about 2s. 1d. per ton. It would be a very great saving to receive from the makers cement which did not involve that cost of handling. He did not know that as an engineer he would care to take cement in bags straight from the manufactory and send it on to any constructive work—probably no engineer would be bold enough to do that; he would prefer to take the cement out of the bags and keep it for a week, instead of the four weeks or five weeks as at present before it was considered cool enough to put into the work. During hot dry weather it had frequently been found that the cement could not be used even after that time, but had to be kept in the cooling sheds for seven, eight or even ten weeks. Any process which would save the time thereby lost would be invaluable.

Mr. W. H. Stanger, in reply to the discussion, remarked that as a person who was responsible for something like 4,000 tons or 5,000 tons of cement a week, as one of those disagreeable people who had to examine it, to test it, and to reject a large quantity of it, he was bound to say that it was quite time English manufacturers did waken up. The old-fashioned kiln would not do; a great deal too much under-burnt cement was produced by it. In the rotary process there was practically no under-burnt stuff. If there was one thing which engineers objected to more

than another it was unsound cement which needed to be turned over, involving an expenditure of 2s. or 3s. per ton. He believed that the newer process with rotary kilns, if properly worked, would effect a great saving of cost to the manufacturers by diminishing the quantity of cement rejected, when they were dealing with specifications written by people who knew what they wanted and intended to get it. It would save not only delays and trouble in that way, but a considerable amount of money in the improvement of the product.

Mr. Bertram Blount considered that the president had touched on what was really for engineers the kernel of the matter. Cement could be prepared by the manufacturers in a perfect state for the users, and could be turned out uniformly correct; it could be taken direct from the kiln to the grinding machinery, packed into bags and made into concrete, and that concrete would be sound. To members of the institution he could not imagine a better recommendation.

In reply to questions raised in the discussion, it might be observed that the clinker lining of the burning cylinder was patched from time to time during the working of the kiln. With such patching, which might occupy on an average 1 hour in 24, the life of the lining proper—that was, the firebrick lining—would be indefinitely prolonged. In actual practice it had been in use as long as two years without needing repair. A great advantage was thus secured in what was practically a permanent lining; the frequent and costly repairs of the firebrick lining of ordinary fixed kilns were abolished. With regard to the means for supporting the cylinder, the illustrations were purely diagrammatic, and were not meant to convey that the kiln was carried on only two points. As a matter of fact four points were used. The authors concurred in Mr. Atkinson's views concerning the method of burning coal dust used by the Atlas Co. They regarded it as one of the most striking and meritorious features of the process and as conducing largely to its success. It was well worth considering whether this method might not be usefully applied in other industries.

Mr. Atkinson's suggestion as to the formation of a soda-lime glass was interesting, and should be the subject of experimental inquiry. The retention of the clinker coating in place was no doubt aided, as Mr. Atkinson had suggested, by the fact that the coating, when completed, constituted a circular arch. It was possible that a saving in fuel might be effected by drying wet slurry in an apparatus distinct from the kiln, but it would be achieved with some sacrifice of simplicity. They agreed with Mr. Redgrave that the plant of all existing works in this country might be regarded as antiquated and indeed practically obsolete, and were of opinion that it would be necessary to substitute a well-designed rotary process such as that described in the paper.

The authors considered that the use of an iron lining for a rotary kiln was wholly impracticable; the conditions were entirely different from those obtaining in fixed vertical kilns, which were sometimes constructed of this material. They feared that Mr. Gilbert had not fully grasped the true causes of the superiority of the rotary system. These were set forth in the paper. They were well acquainted with the Schneider kiln, which was a good example of those fixed kilns which were now on the verge of extinction. The rotary process was as freely used in the United States on wet raw materials as on dry raw materials, and with equal success. It was scarcely reasonable to suppose that mere translation through a certain longitude would affect the working of the plant, and on no other ground with which they were acquainted could it be contended that a well-contrived rotary process would fail to work in England. Therefore they must dissent from the suggestion that their recommendation of cement made by the rotary system was in any way premature. It was well to receive innovations with caution, but there was a point where caution degenerated into inaction. Progress then became impossible.

It was correct that experiments had been made by Messrs. Hurry and Seaman on the production of cement clinker by actual fusion in a blast furnace. The principle was sound, but the difficulties of realizing it in practice were likely to prove severe. According to their latest information the process was still in its experimental stage. Knowing the skill and perseverance of the inventors and the financial resources of their company, the authors would not be surprised to learn of the ultimate success of the process. From the fears which Mr. Reid entertained as to the success of the process in this country it was evident that he had hardly realized the situation. The rotary process was at work in America on wet raw materials—chalk and clay—identical with those used here, as well as on dry raw materials. It had been found by experience to be as easy to handle the one as the other, and the difficulties suggested were imaginary. The old plan of plastering the walls of fixed kilns with slurry differed radically from the Hurry-Seaman method of providing an efficient protective coating of clinker for the firebrick lining of a rotary kiln. The essence of the latter procedure was the heating of the firebrick and the application thereto of plastic clinker; in the former the walls of the cold kiln were simply daubed with slurry in the hope that some might stick and hinder to some extent the action of the clinker when the kiln was heated.

The suggestion of a water jacket was interesting, but only academically so, for the lining difficulty which it was designed to overcome did not now in fact exist. The extreme lip of the kiln which projected into the burner chamber, where it was exposed to a good deal of heat, was cooled by a water ring in the Hurry-Seaman plant, but this was to protect the end of the metal shell, and had nothing in common with the water jacket to serve as a substitute or protection for the lining.

The authors were glad to find Mr. Butler in agreement with them as to the necessity for abolishing the old uneconomical discontinuous process. As he had surmised, they had had in their minds chiefly Continental practice when speaking of the Dietsch kiln. It was certainly curious that English manufacturers had never taken kindly to an apparatus which had undoubted merits for appropriate materials and conditions. Mr. Butler's calculation of the quantity of water, additional to that naturally present in the raw materials, which was necessary to form a slurry scarcely gave an adequate expression of the facts. It was true that there might be only 10% of this additional water calculated on the slurry, but it must be remembered that this corresponded with about 20% calculated on the dry raw materials, which was the real standard of comparison. An example might make this clear. If a chalk containing 20% of water were mixed with a clay containing 45% of water in the usual proportions so as to yield a mixture which, when dry, contained three parts of dry chalk to one part of dry clay, the mixture in its natural wet state would contain water amounting to 39% of the weight of its dry constituents. If, however, this natural wet mixture was washed so as to form what was commonly termed a 40% slurry—i. e., a slurry containing 60 parts by weight of dry raw materials and 40 parts by weight of water—it would contain water amounting to 67% of the weight of its dry constituents—that was to say, the water had been increased by a quantity amounting to 28% of the dry slurry, or 72% of the original quantity of water naturally present. Thus the additional water to be evaporated was a more formidable amount than would be suspected from Mr. Butler's method of expressing the same facts. The possibility of avoiding this addition of water had been touched on in the paper, and the difficulty of removing the flints had been adverted to, but the full discussion of the question did not fall within the present intention of the authors.

The process of adding to the clinker a small and regulated quantity of water was undoubtedly advantageous. During the grinding of the clinker the water was perfectly distributed, and fulfilled its office of slaking any unsaturated lime compounds which might be present. The tests of Atlas cement quoted in the paper certainly indicated a marked superiority to ordinary English cement made by the old process, especially in regard to that most important quality, soundness. This soundness was secured by the regularity of burning and the systematic moistening described in the paper. Mr. Plaister's conclusions as to what constituted economical and rational manufacture of cement material might have been considerably modified had he been allowed to visit the Atlas works. The authors were acquainted with the practice obtaining in every typical rotary cement works, not only in America, but on the Continent; and they could say without hesitation that in none which they had visited, or concerning which they had obtained information, was the systematic, continuous and economical handling of materials from crushers to barrels carried out with any approach to the degree of perfection attained on the Hurry-Seaman system. In like manner, though coal was being everywhere adopted, yet there was at the present time no burner to be compared with that employed at the Atlas works. There was no reason to suppose that improvements in this and other respects would not be made, but obviously the authors must confine themselves to a description of the industry in its present state, and not indulge in vaticination. Had Mr. Plaister had access to the sources of information open to themselves he would have been less surprised at the statement of costs which had been given.

The authors concurred with Mr. Leedham White's view that manufacturers of cement had of late years shown themselves eager to improve their methods both in point of economy and in quality of product. The present enterprise of the Associated Portland Cement Manufacturers (1900) Ltd. in adopting rotary kilns was certainly commendable, and they hoped that, before long, many of the other works under the control of that body would be provided with modern plant.

DISCUSSION BY LETTER.

Mr. E. Candlot, of Paris, remarked that there was no doubt the rotary process of burning marked a considerable advance in the manufacture of Portland cement; but the resulting economy should not be exaggerated. The figures given by the authors for the quantity of fuel required by the older process for power and for burning, viz., 17½% and 43% respectively, might be correct for English manufactories, but they were certainly not so for French, German, or Belgian works. The maximum consumption of fuel by a well-equipped Continental manufactory, using wet materials containing 45% of water, was 10% to 12% for power and 28% to 30% for burning. In works using dry materials it was 15% for power and 18% to 20% for burning (with Schneider or Timm kilns using bricks direct from the presses and containing 9% of water). This would considerably affect the calculations of the advantages of the rotary process. He believed also that the figure given in the paper for the amount of fuel required for burning by that process (30%) was too low. In all American works which he had visited the amount had been greater, and had sometimes reached 60%. This, of course, referred to kilns 60 ft. in length; an important economy of fuel was obtainable with longer furnaces; but he did not think that the consumption could be reduced below 35%. The fuel required for power purposes appeared to him to have been underestimated, as rotary furnaces required a considerable amount of motive power, not only for rotating the cylinder, but also for crushing coal, drying, transporters, fans, etc. Further, it must be taken into consideration that only a special kind of coal, containing a certain quality of volatile matter and yielding very little ash, could be employed in the rotary process; in some countries such coal was costly. On the other hand, with the ordinary furnaces, coke or anthracite could be employed, and sometimes fuel containing as much as 25% of ash was utilized. In his opinion the maximum saving realized with the rotary kiln was between 1s. 7d. and 2s. 5d. per ton under the most favorable conditions; that was to say, coal being cheap and labor dear. With reference to the author's statement as to the output of the Schneider kiln, he pointed out that kilns provided with forced draft on the Hauenschild system easily turned out 120 tons per week; the Timm kiln, which belonged to the same class, produced as much as 150 tons per week; and the Hoffmann kiln had an output of 70 tons per day—a kiln with 20 chambers producing 450 tons to 500 tons per week.

Mr. A. E. Carey remarked that the use of the rotary system in Germany was firmly established and was rapidly increasing. The authors had merely made a passing reference to that system as now carried on at Hemmoor. It was there in regular use under the wet system of manufacture, the kilns being 98 ft. in length. It was very doubtful whether the so-called patent rights in rotary kilns could be maintained if disputed, and the authors did not describe any features which could be called unquestionably novel and patentable. The covering of the lining of fixed kilns with salt and the use of an adherent coating of clinker as a protection to the lining were extremely old expedients; in fact, the rendering of the inside of cement kilns with slurry (which on burning, of course, became clinker) was probably coeval with the manufacture, and the only suggestion of novelty made by the authors was the beating of the clinker in a hot state onto the lining of the rotary kilns. In Germany, however, the difficulty of getting the kiln lining to stand appeared to have been overcome without resorting to this practice. The moistening of the clinker as it came away from the kilns was also quite an old expedient. Setting aside as indisputable the fact that by the rotary process cement of the highest quality could be made, although excessive power was requisite for grinding under that process, the whole matter resolved itself into one of cost of production; and the authors did not anywhere state the capital outlay necessary for the installation of the Hurry-Seaman system, nor attempt to compare it with the old system of kilns. The figures given had exclusive reference to the cost in fuel and labor of manufacture, and it must not be forgotten that the statements contained in the paper, so far as they related to the rotary process, were in the nature of estimates or ideal statements. The question of the life of the structure of the rotary kiln as compared with that of the fixed kiln, and of the amount of depreciation which therefore should be allowed, were points as to which data did not exist at present. There was no doubt that no hard and fast rule could be laid down that any one process of manufacture was of such proved superiority as to be likely to hold the field exclusively; the local conditions of cost and the nature of the raw materials and fuel, as well as the cost of labor, must remain vital factors in deciding the most suitable type of installation for any particular locality.

Mr. W. F. Goreham remarked that the Hurry-Seaman burning plant appeared to contain only two novel features worthy of notice. The covering with clinker of the brick lining of the burning cylinder was an old practice. One well-known firm some 15 or 20 years ago appeared to have realized the value of this practice to such an extent that a man had been appointed to a certain number of kilns to go into each one when drawn and while it was hot to pug up the kiln with slurry, with which, however, a certain amount of loam had been mixed. Other firms were said to have used slurry alone for the same purpose. The novelty in this case, therefore, consisted only in the patting down of the clinker when in a plastic state. He understood that at Hemmoor, however, no such means were taken to protect the lining. Kilns existed in which there was no lining whatever in the shape of bricks, etc.; the walls of the kiln being formed of cast-iron rings, which were prevented from reaching a melting heat by having outside gills, such as were used in ventilators, to present a large cooling surface to the air. Such kilns had been adopted in a large number of the new burning plants or extensions of existing plants erected in Belgium during the past year or two, practically the whole of the exten-

sions in that country taking the form of shaft kilns. In this type of shaft kiln the cement did not stick to the sides of the kiln. In another cast-iron shaft kiln holes were made through the rings, but as to the success or failure of this type there appeared to be little or no data. The cooling cylinder was, of course, not new, and although it was apparently a very good attempt to reduce the loss of heat which appeared to be unavoidable with the rotary system, it did not altogether prevent that loss, as was proved by the fact that the system consumed 50% more fuel—this being prepared coal instead of coke—than shaft kilns. The second apparent novelty consisted in making the crusher part of the kiln and wetting the clinker there. There was nothing new in putting water on the clinker at the crusher, and in his opinion the retention of the crusher at the mill and the addition of water to the clinker there was preferable; but apparently one of the reasons for doing this at the kiln was to cool the clinker by taking up as much as possible of the heat that was wasted with the rotary system. Mr. Goreham's preference for watering the clinker at the crusher when forming part of the mill was based on the result of experiments he had made some years ago by taking clinker crushed small, soaking it in water for a time, then drying it and grinding it in the ordinary way. This had passed practically the same tests as if it had not been wetted, proving that the water had no effect on the cement until it was ground to the marketable form, and it appeared that there would be far less chance of the water having the desired effect if it were added to the hot clinker at the kiln—and therefore subject to varying delays before reaching the grinding machines, and to irregular evaporation on the material, even if added in larger quantities—than if it were added at the crusher at the mill and so delivered at once into the hopper for grinding.

Mr. H. Le Chatelier had had occasion to investigate the subject of magnesia refractory linings. Their use gave rise to two grave difficulties, which did not appear to be always sufficiently understood. The coefficient of dilatation was very high, and the result was that considerable pressure between the lining and the metal cylinder of the furnace occurred during heating, and the contraction during cooling ruptured the refractory lining and tended to its disintegration. The results of his measurements of the dilatation of magnesia bricks from Euboea, and of bricks of ferruginous magnesia from the Tyrol were:

Temperature.		200° C.	400° C.	600° C.	800° C.
Dilatation in millimeters of a bar 100 mm. long.....	Euboea.	0.21	0.55	0.85	1.1
	Tyrol...	0.25	0.52	0.79	1.02

showing that the dilatation was sensibly the same for the two varieties of magnesia brick, and double that of fireclay bricks. Another important point was that the ferruginous material which agglomerated the Tyrolese bricks melted at a certain temperature and remained indefinitely in the liquid state, provided the temperature did not fall. The result was that at high temperatures these bricks had very little durability, and were in fact in a pasty semi-liquid condition. Pure magnesia bricks, however, even if softer under ordinary conditions, retained a much greater degree of solidity when heated. The behavior of basic bricks was quite different from that of silliceous refractory bricks. The fusible elements contained in the latter dissolved increasing quantities of silica, forming vitreous matter more and more siliceous and less and less fusible. The result was that the materials melted at the first heating solidified progressively by absorbing silica. Basic materials, on the other hand, which did not assume a vitreous condition, did not have the same effect.

Mr. E. Macoir, of Niel-on-Rupell, remarked that, having been acquainted with the rotary process in use in the United States during the past 15 years, and having seen it at work on the Continent, he had always considered it as destined to replace some day, particularly in the construction of new cement works, the processes hitherto in use for wet as well as dry material. There had remained, however, two important improvements to be made in the plant in order to arrive at this result, viz.: the provision of means of controlling the temperature in the kiln and of obviating the destruction of the lining. Apparently the happy modifications introduced by Messrs. Hurry and Seaman had met these requirements, and had rendered the process more practical and economical. The process of watering the clinker completed the series of entirely mechanical operations of manufacture, and enabled a perfectly sound cement to be produced direct from the works without recourse to the slow, cumbrous and costly process of aeration. The kilns of Messrs. Hurry and Seaman appeared to him to remedy in a favorable manner the inconveniences which had been found to arise in the working of the older forms of rotary kiln, and to ensure, by regular and practical steps, the advantages of the latter, consisting notably of a considerable economy in fuel and, above all, in labor; and there could be no doubt that these kilns, properly worked, gave excellent results.

Dr. Michaelis, of Berlin, recommended the formula

$$\frac{CaO}{SiO_2 + Al_2O_3 + Fe_2O_3} = 2.5,$$

instead of the ratio of basic to acid oxides given by the authors as expressing the approximate composition of a good cement mixture. However completely the mixing and burning might be effected, the ratio $\frac{CaO}{SiO_2 + Al_2O_3} = 3$ should never be attained, as this always resulted in the production of blowing cement, because Al_2O_3, $3CaO$, even when it was completely fused, should only be hydrated with very considerable increase of volume. The treatment of the clinker with a small quantity of water, about 1% by weight, had been practiced in Germany for the past 25 years, and this plan had been universally adopted there for the past 10 years. In the early eighties he had introduced the method into the works of the Compagnie Nouvelle des Ciments Portland du Boulonnais in France, which he had built; and it had also been used for some years in England on his advice. Basic linings of cement clinker in the Dietsch kiln had long ago been tried in Germany, but had not come into any considerable use, owing to their slight durability; such a lining was easily disintegrated by cooling of the kiln, and prolonged heating reduced it to powder, especially when it became less basic through taking up ash from the fuel used. The most satisfactory method of making the lining would obviously be to cast or mold bricks from fused Portland cement, since that was much stronger and more durable, or else to use bricks having the composition

$$\frac{MgO}{SiO_2 + R_2O_3} = 2.5 \text{ to } 2.8.$$

He fully shared the authors' favorable opinion of the rotary process, and had expressed his views in similar terms before the Verein Deutscher Portland-Cement-Fabrikanten. It was desirable that the burning should be effected by the use of gas instead of coal dust. In this way the quality of the product could be considerably improved, because the composition of the mixture could be kept perfectly regular, whereas with coal-dust firing it was subject to uncontrollable variations, owing to varying quantities of ash from the fuel. Gaseous fuel must, however, be always more costly than coal dust, because gasholders were needed to maintain a uniform pressure, and their introduction must be the cause of loss of heat.

high-pressure fan and terminating inside the [illegible] in a broad nozzle which was capable of being moved [illegible]ically. The coal dust was fed regularly into the stream [illegible] air by means of an apparatus which could be easily [illegible] rolled from the burning cylinder, and thus a uniform [illegible]keting temperature was maintained over a certain zone [illegible] position of which could be altered at will by means [illegible] of the adjustable nozzle.

The consumption of fuel in the production [illegible]ement from blast-furnace slag and limestone, including [illegible]ost required for drying the raw materials, was, with [illegible]out interrupted working, materially less than the 30 [illegible]% of the weight of the clinker given as the consumption [illegible] American conditions and the use of marl. With regard [illegible]to the lining of the burning cylinder, the material used [illegible] for this purpose had, from the first, been one containing [illegible] 30 to 40% of Al_2O_3. In the course of the work the production of a clinker-like coating on the lining itself had been observed, and its exceedingly favorable effect on the durability of the lining of the clinkering zone had been quickly noted. Accordingly subsequent operations had been directed with a view to the speedy production of such a protective coating. Like the salt used in the Hurry-Seaman process, the coating of finely-divided ash, formed on the lining of the kiln when first fired, softened the firebrick lining and facilitated the adhesion of the cement material. For a considerable time past the practice of introducing ordinary cement material in the first place had been given up, and, instead, the fine and more easily fusible material carried over into the dust chamber of the kiln and there mixed with fine ash, had been used, which had proved to be preferable for the production of the desired protective coating. The success which under other circumstances might certainly have been looked for with this lining had not, however, been realized, as the kilns and the machinery connected therewith had been subject to frequent stoppage. The stresses set up by the cooling, owing to the different expansibilities of the three layers, viz., the firebrick, the cement clinker, and the vitreous layer between them, of course caused continual detachment of the clinker lining, which, in frequent alternation

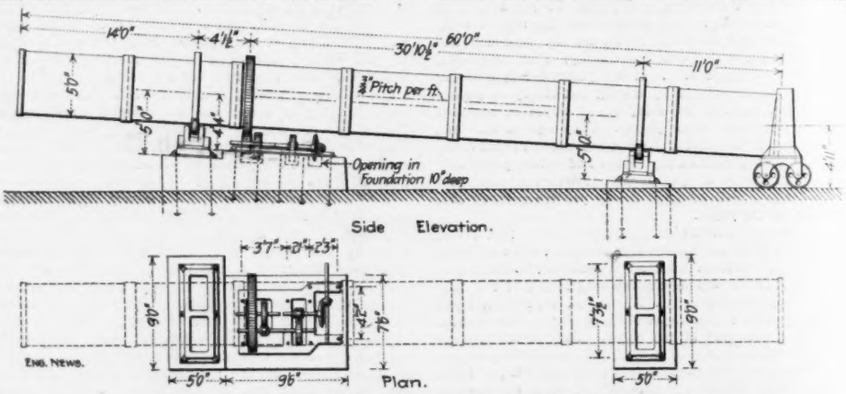


FIG. 7. PLAN AND ELEVATION OF ROTARY CEMENT KILN.

The cement produced by the rotary process, even with coal-dust firing, was, for the reasons advanced by the authors, actually of better quality than could be attained, as a rule, with the processes hitherto employed. Even if the specially favorable circumstances which in America had conduced to the attainment of a successful result in a comparatively short time, viz.: the low price of coal and the high price of labor, did not obtain in other countries, or did so in a much smaller degree, yet, apart from this, the whole process of manufacture was so much simplified, concentrated and made independent of the will and skill of the workmen that there could be no doubt the rotary process would produce a cheaper and better cement in those countries also. The fewer the workmen needed in an industry the greater the certainty with which its operations could be carried on; and there was little risk of making a false prediction in advancing the opinion that in a short time this rotary process would make triumphant progress over the whole world.

Mr. F. Schiele, of Giessen, had been much interested in the paper, and had found mentioned in it, almost word for word, all the difficulties which his own firm had experienced and had had to overcome; and, on the other hand, the remedies which they had discovered in some instances agreed almost exactly with those mentioned in the paper, although they had worked quite independently of American investigators. Immediately after he had taken over, in July, 1897, the management of the construction and working of the first cement works with rotary furnaces erected in Germany, at Lollar, the necessity for an efficient method of burning which would give a uniform high temperature, in order to obtain clinker of a good regular quality, had been evident. For this purpose only the method of coal-dust firing under pressure had been known, the working of which from the first had proved to be superior to other methods and entirely satisfactory. In his practice the burner consisted of a tube connected to a with its re-formation, must result in partial destruction of the firebrick beneath. The alterations necessary to obviate the mechanical difficulties had for some time been settled and were being carried out. The authors had justly laid stress on the importance of the regular and uninterrupted working of rotary furnaces, which was desirable not only in regard to output, but also on the ground of economy of fuel and preservation of the costly kiln linings.

Mr. W. H. Simmons remarked that decided changes had been made in the Bronson Portland Cement Co.'s method of manufacture since he had begun his duties as chemist to that company early in 1900. The shale clay had been rejected as being too high in alumina, and a plastic clay had been found which was lower in that constituent by 30% of itself. Petroleum was no longer used as fuel, but pulverized coal, fed by a blast of warm air, had superseded it. The coal used contained about 9% of ash, but this, it was found, did not need to be considered in computing the mix of slurry. The fuel was very finely ground and was fed into the cylinder just above the center of the end, and the resulting ash was nearly all carried through the cylinder, and fell into a pit just beneath the stack for gases. The company had introduced a rotary cooler, with a blast of air through it, which was very satisfactory, and the clinker, falling from the cooler into a wagon, was dumped into an elevator which carried it to the grinding mills. By this method the expense of much handling was avoided. The clinker was sprayed with water as it passed along the pan conveyor from the rotary kilns to the cooler. They still used the magnesite brick for kiln lining, but found that these could be made to last much longer than formerly by the following method. When first starting a kiln, a slurry was prepared which was about 2% lower in lime than that which was usually burned. This, of course, burned at a much lower temperature than the usual slurry, and in the course of a few hours formed a coating over the brick. After the

coating had been secured the temperature of the kiln could be raised, and higher-limed slurry could be burned successively without in any degree injuring the brick lining. This lining or coating of clinker would adhere to the brick as long as the kiln was kept in operation, but if permitted to cool it would crack and scale off.

Mr. Charles Spackman observed that only two mills had been taken as typical of the cylinder-fired cement plant of the United States; the works of the Atlas Cement Co., representing the largest and most successful plant using the dry process, and that of the Bronson Cement Co., manufacturing by the wet process, being generally considered to be one of the least successful of this latter type. In briefly reviewing the history of the introduction of the rotary kiln into America, honorable mention should be made of the name of Mr. Pierre Giron, who had been the superintendent of the Atlas company from its inception, and who, while the works were owned almost exclusively by Mr. Navarro, had so far perfected the Ransome process as to place it beyond the experimental stage and to produce a stable and high-quality Portland cement, burned with crude oil. Mr. Spencer B. Newberry likewise deserved credit as the pioneer of the rotary process, employing wet slurry and burning with oil. In the works at Warners, N. Y., he had made use of a double set of rotary kilns, one set being employed for drying the wet slurry and the other for the calcination of the clinker. For various reasons this plant had never proved a commercial success, but after his connection with this undertaking had been severed Mr. Newberry had erected a small works at Bay Bridge, near Sandusky, O., and there he had likewise employed two 40-ft. cylinders with a double system as before. He had afterwards riveted together the two sections into a single cylinder, 80 ft. in length, into which he had introduced the wet slurry. This had been done in 1893, but after many experiments he had become convinced that kilns of this length were quite unsuitable for the process.

Messrs. Lathbury and H. S. Spackman also deserved mention for their experiments in burning wet slurry in the Lehigh region. As early as 1895, Mr. Lathbury had been conducting a series of trials, extending over four months, at the works of the Alpha Portland Cement Co. in the use of pulverized coal as a substitute for crude oil, which previously had been exclusively employed as fuel in all the rotary kilns in America. These experiments had been successful, and the company had decided to put down a plant for coal-dust fuel. A mechanic employed at the Alpha works had entered somewhat later the service of the Atlas company, and rival patents for this process, applied for in the interest of both companies, had failed. The application of the Alpha company had been, however, some six months earlier than that of the Atlas company; the priority of the invention was claimed for both these concerns. No other cement works had used pulverized coal until the completion of the Castalia works in Ohio in 1897. There was now only one rotary plant in the United States using oil fuel, and this was situated in California, where the price of coal exceeded that of oil. The works at Castalia were in the vicinity of those already mentioned at Sandusky. The Castalia plant, designed by Messrs. Lathbury and Spackman, comprised four rotary kilns, 5 ft. in diameter and 60 ft. in length; the cement was manufactured by the wet process from a finely-ground mixture of coarse granular marl and blue clay, the fuel being pulverized coal.

About the same time these gentlemen had been making experiments with the use of blast-furnace slag and limestone, in order to determine whether it was possible to burn these materials in a rotary kiln and thus to produce a good quality of Portland cement. These experiments had ultimately proved successful, and in the early part of 1898 works had been started for the Clinton Cement Co., connected with the Clinton Iron & Steel Co., in Pittsburg, Pa. Although the total output of suitable slag was but small, the cement produced, ever since the works had been completed in the autumn of 1898, was quite undistinguishable from Portland cement of the highest quality. The raw materials were burned in cylinders in a dry state with pulverized coal. The slag was subjected, previous to drying and grinding, to a thorough washing during granulation, in order to free it as far as possible from the sulphur compounds. The limestone mixed with the slag was that originally supplied to the Bessemer furnaces, and contained about 95% of calcium carbonate.

About the period of the completion of these works the same engineers had designed and started a plant of their own at Wellston, O., in order to manufacture cement from limestone and clay by the dry process, using pulverized coal. These works, known as the Alma Portland Cement Co., which at the time of their establishment had evoked considerable adverse criticism in respect of the process adopted, had been in successful operation for three years. It had been asserted by experts that limestone and clay could never be burned together in cylinder kilns in a dry state, as a separation of the two ingredients would necessarily follow when subjected to the full blast, but this opinion had been proved to be entirely erroneous in practice.

Messrs. Lathbury and Spackman had likewise designed plants at the Michigan Alkali Co.'s works for the production of Portland cement from soda waste and clay, and a small factory at Milton, N. D., to produce cement from calcareous earth. Some interesting experiments were also in progress under them as to the use of different kinds of coal in the cylinders, the governing factor being of course the percentage of ash; the sulphur had not proved in any way troublesome. Certain kinds of coal had, owing to the amount of ash, tended to increase the percentage of silica in the product so greatly as to render their employment impossible. Messrs. Lathbury and Spackman had during the past winter been testing at their factory, on a commercial scale, coal, limestone, and clay brought from Japan; the results had proved excellent, the coal especially being equal to the best descriptions found in America.

The majority of the rotary-kiln plants in the United States worked their grinding department for clinker, as well as their kilns, on Sundays and holidays. Although there were several cement mills in which cylinders of 60 ft. in length were employed, having two different diameters, 6 ft. for the front and 5 ft. for the rear end, nearly all the kilns now constructed were of this length with a continuous diameter of 6 ft. throughout. The inclination of the kiln varied considerably, in accordance with the nature of the raw materials in use. Cylinders in which marl and clay were treated by the wet process were generally set at a gradient of ½-in. to the foot; while in the case of the argillaceous limestone of the Lehigh region, used in a dry state, an inclination of between ¾-in. and ⅞-in. per foot was found best. The speed at which the kiln was driven varied with the inclination and the nature of the materials, but it should be under the complete control of the burner, and the best results were obtained by using speed regulators (cone reduction apparatus) on the driving gear for both kiln and coal feeds, so that the burner could change these details at will.

In the greater number of the rotary kiln plants at the present time the coal was dried either in rotary dryers or in some form of tunnel. The cylinders for coal drying

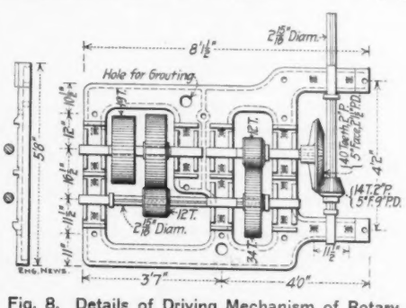


Fig. 8. Details of Driving Mechanism of Rotary Cement Kiln.

were commonly 40 ft. in length and 4 ft. in diameter. They resembled the kilns, but were used without a lining. Instead of forcing in pulverized coal, an ordinary firebox was applied at the discharge end and the hot gases passed through the rotary dryer into the chimney shaft at the far end. There were, however, two small plants in which the coal was ground in a high-speed centrifugal hammer-disintegrator, sufficient air being provided by the revolution of the hammers to force the coal-dust directly into the cylinder, one such machine being installed directly in front of the discharge hood of each kiln. Though this plan had several disadvantages, it was said to involve only one-third the cost of an installation of rotary drying and tube-mill grinding plant for the coal, but it was rather wasteful of fuel.

Nearly all the principal manufacturers first reduced the coal in a rough crusher or disintegrator and then passed it into tube mills to be ground with flint pebbles. The earlier works employed the Griffin mills, and the Atlas Co., who owned and controlled the Huntingdon mill, were the only users of that form of grinding. The best results were no doubt obtained by the use of tube mills.

Very great attention had been directed by cement makers to the subject of kiln linings. Excellent results had been obtained by the employment of a special firebrick, consisting of about 41% of silica and 49% of alumina; as this was but slightly acid, due to the high alumina contents, it avoided the risk of fluxing to which the authors had alluded. The analysis given in the paper represented a type of firebrick certain to give rise to continual difficulties. Experiments had been made as early as 1894 to produce linings for the cylinders consisting of bricks, compounded of a mixture of cement clinker ground to pass a ¼-in. mesh and Portland cement. The results had, however, not been wholly satisfactory. The method of covering the bricks with a protective coating of clinker, as described, was not generally followed at the present time, but skilful burners could coat the bricks with a deposit of molten slurry, which subsequently served the same purpose. The employment of magnesia bricks, formerly used for cylinder kilns adapted for the wet process, had been totally abandoned, chiefly because the bricks were found to shrink in use and speedily fell out of their places.

Many plans were practiced for the regeneration of the waste heat from the clinker. One of the most successful depended upon the use of masonry vaults placed directly underneath the discharge hood of the kiln. These vaults had sloping floors, outlets from which opened into a tunnel. Cold air was forced from the lower level of the vaults, and passing thence through the pile of hot clinker it became heated so that it could be drawn off and forced back into the kilns, mixed with the pulverized coal. The use of a jet, spraying water upon hot clinker, was quite unnecessary if the raw materials were thoroughly mixed and pulverized and the clinker was properly burned. At the best, it was only a makeshift, and the process was not now carried out in any of the leading works; the few makers who had once tried it in America had in most cases abandoned it.

In the matter of fineness of grinding, the following tests could be imposed: 20% residue on a 200 × 200-mesh sieve; 5% residue on a 100 × 100-mesh sieve. The authors appeared to be somewhat low in their estimate of the cost of manufacture per ton of cement. It was not now possible with the best descriptions of cylinder kilns to turn out cement at less than 60 cts. per barrel of 380 lbs., say, $3.54 for 2,240 lbs. The cost of the rotary process for wet slurry was greater than would be the cost of burning the same material in vertical kilns of the Schoefer type, owing to the increased consumption of coal.

The authors did not seem to be well informed respecting the high efficiency and the standard of excellence attained in plants other than that of the Atlas Co. Among these might be mentioned the works of the Lehigh Portland Cement Co., at Ormrod, Pa., using materials similar to those employed by the Atlas Co. and burning dry. This plant had two separate mills, with a capacity of 4,000 barrels a day. There were several rotary plants, among which were the Saylor (3,000 barrels per day), the Alpha (2,500 barrels), the Vulcanite (2,000 barrels), and the Lawrence Co. (1,500 barrels per day), all using argillaceous limestone, which could show cost sheets as low as, if not lower than, those of the Atlas Cement Co.

As regarded the method of handling coal, it was quite true that fans were commonly employed, and they could be used with good effect. Only one other company was now using compressors, namely, the Virginia Portland Cement Co., of Craigsville, Va. By both of these systems a proper control of the temperature could be insured, and the fans were much less costly in use.

Producer gas had been found to give poor results, but natural gas was being employed at the works of the Iola Portland Cement Co., in Kansas, as adapted to a cylinder plant. The entire machinery of these works was operated by gas engines, and the undertaking was being followed with great interest by cement manufacturers, as the cost was at least 30% lower than that of any other cement works in the country.

In the case of slurry plants, although it was customary to line the cylinders with firebricks throughout their length, there was nothing to be gained by employing the lining all through the kiln. Good results were being obtained from 60-ft. kilns, with a lining 9 ins. in thickness for two-thirds of their length. The heat at the rear end was not sufficiently intense to buckle the steel plates.

There was a general consensus of opinion in America that the prolongation of the cylinder kiln for the production of clinker from slurry was entirely unsatisfactory. The authors had been misled in their statements that practice had demonstrated that there was the same coal consumption both with dry and with wet materials. For the former the coal needed was about 25% to 30% by weight of clinker produced, and for the latter it ranged between 40% and 45% by weight of the clinker. The reason that long cylinders operating on slurry failed to give satisfactory results, both in production and in coal consumption, was, as careful experiments had demonstrated, that within 10 ft. of the point at which the slurry entered the kiln the moisture was entirely driven off. Samples taken at intermediate zones of 5 ft. in length showed little change in the chemical or physical condition of the raw material up to a point within 25 ft. of the head of the kiln or 35 ft. from the rear end. At this point the carbon dioxide began to be expelled, while the real clinkering took place within a zone of 15 ft. from the fuel pit. When the kiln was extended beyond 60 ft. in length, the temperature of the waste gases was correspondingly reduced towards the rear end of the cylinder and tended to reprecipitate the moisture in lieu of carrying it off into the chimney. There were no mechanical difficulties in supporting or in providing for expansion in the use of a kiln 90 ft. or even 100 ft. in length, but such kilns were of little or no practical use. For many of the foregoing statements he was indebted to Mr. Lathbury, whose opinion on these processes was of high authority in the United States.

The authors, replying to the correspondence, wished to point out that some of the writers had hardly appreciated points which were clearly set forth in the paper. In some instances correspondents had failed to realize that the economy of working of the Hurry-Seaman process was not derived from a mere estimate, but from the actual working cost for an output of many thousand tons. They had read with much interest Mr. Candlot's remarks, and

agreed with him that in most American works the amount of fuel used was extravagant. In the process carried out at the Atlas works the consumption seemed still extravagant when the actual quantity of heat needed was taken as the standard; nevertheless it was reasonable, compared with the 60% cited by Mr. Candlot, being indeed only 30%. Mr. Candlot was mistaken in supposing that a particular quality of coal was needed for the rotary process, or that the proportion of ash was of importance except as diminishing the calorific value. His estimate of the saving to be effected by a well conducted rotary process was much below the mark, the reason being that those rotary processes which were public property were not particularly well devised and were by no means systematic, whereas the Hurry-Seaman process, of which the authors had made a somewhat close study, possessed both these qualities. They took this opportunity to say that though the rotary process was sound in principle, its application took many forms which were far from economically acceptable in practice. In their paper, with a knowledge of every typical rotary process, they had selected one which, in their opinion, most nearly approached a good standard of efficiency, and their statements of cost were based on this and not on the results obtained by imperfect application of the same general method.

Mr. Carey might dismiss from his mind the idea that the results of the rotary process in American practice were not easy of attainment under English conditions. They concurred that there were no patent rights in rotary kilns as such, but there were important patent rights in the arrangement of the kilns and in the methods of firing them and handling the product. They must dissent altogether from his view that the old plan of plastering fixed kilns with slurry had anything in common with the systematic and controllable coating of rotary kilns with clinker; the latter procedure had been fully described in the paper. Moistening clinker in a haphazard and ineffectual manner had been practiced for many years, but regulated and effective moistening was a modern development. The old process was largely directed to quenching silicates which would otherwise have "fallen," and was conducted without proper knowledge of the true advantage to be obtained. Moreover, clinker in large lumps did not lend itself to systematic sprinkling; it was only well made rotary clinker which was capable of absorbing and utilizing the regulated proportion of water applied on it. The figures given in the paper as to cost of production criticised by Mr. Carey were taken from actual records of important works; they were in no sense arbitrary figures or mere estimates. The authors, therefore, though freely admitting that local circumstances might cause increase or decrease of items going to make up the total, were of opinion that the cost given might be taken as an accurate guide under average conditions.

The kilns mentioned by Mr. Goreham, which were composed of vertical cast-iron segments, were fixed kilns, and in no way comparable with rotary kilns. This mode of construction, as stated in the authors' reply to the oral discussion, was not applicable to rotary furnaces.

The authors were indebted to Mr. H. le Chatelier for his interesting data concerning the expansion of magnesia bricks. The defects on which he commented had doubtless contributed to difficulties experienced in utilizing these bricks for cement kiln linings. Happily, by the adoption of the method of protecting common firebricks described in the paper, the need for employing magnesia bricks had ceased. Mr. Macoir had fully realized the causes of the success of the Hurry-Seaman process; its comprehensive system, its continuity, its automatic operation were factors as potent as were its novel methods of burning, cooling and protecting the kiln linings. Those European manufacturers who, like Mr. Macoir, had this clear understanding of the essence of the subject would not be slow to secure economy by a wholesale modernization of their plant. The authors preferred the ratio established by Mr. H. le Chatelier to that proposed by Dr. Michaelis. There was no evidence that silicates, aluminates and ferrites containing 2.5 equivalents of lime to 1 equivalent of acid oxide existed, whereas tri-basic compounds had been actually prepared. In their own experiments they had succeeded in attaining the ratio

$$\frac{CaO}{SiO_2 + Al_2O_3} = 3$$

very approximately, and cement of this composition had been perfectly sound. In ordinary industrial cements the approximation was less close, but that was no reason why a correct ideal should not be maintained. Dr. Michaelis himself had shown the way in his researches on the properties of fused clinker, and it might well be that in the future all cement materials would be run down to an actual slag. The rotary process would then disappear and would be replaced by an operation conducted in an apparatus of blast furnace type. Mr. Hurry's experiments were now directed to this end. The authors, some 10 years ago, had experimented with lining bricks made of Portland cement, and were of opinion that such bricks had many merits. But to be perfect they needed to be considerably more basic and less fusible than ordinary Portland cement, and the difficulties in preparing them were great. Until success had been attained, a practical evasion of the difficulty was afforded by the Hurry-Seaman method of providing a plastic clinker coating. The use of gaseous fuel adverted to by Dr. Michaelis possessed theoretical advantages, but in practice it was found that, contrary to expectation, the ash of the solid fuel (coal) contributed but little to the clinker; it chiefly passed through the kiln.

The authors had had the advantage of seeing the process at Lollar, near Giessen, described by Mr. Schiele, and were glad to learn that the fuel consumption had been materially reduced. It must be remembered, however, that a great part of the lime in the raw materials was not as carbonate, but in the form of blast furnace slag, and thus the quantity of heat needed was substantially decreased. The difficulty experienced by Mr. Schiele in protecting the firebrick lining was not without parallel, as was shown by the following extracts (translated) from a paper by Dr. Valur, of Hemmoor (where a similar process was worked), read before a meeting of the Association of German Portland Cement Manufacturers, held in Berlin in February, 1901:

> I come now to the repairs, and I must admit that, during the past year, the firebrick lining of the kiln has caused us much inconvenience from stopping the running, and has put us to considerable expense. We found that the firebricks in the clinkering zone required to be renewed every six or seven weeks, in spite of the fact that we tried two different kinds of brick and made the lining of various thicknesses, e. g., 20, 25 and 40 centimeters (about 8, 10 and 16 ins., respectively). The average cost of repairing was 700 marks (about £35), so that for the year 1900 our repairs bill was about 5,000 marks (about £250), corresponding with 14 pfennig (1.68 penny) per barrel of cement produced.
>
> After alterations of the method of burning:
>
> The rate of wear of the firebrick lining was very small, viz.: about 1 centimeter in a fortnight. Therefore, if we assume that a lining 30 centimeters thick is used, and that it can be run until it is only 5 centimeters in thickness, it follows that repairs will have to be effected twice a year, at an annual cost of 1,400 marks (about £70).
>
> Taking the output of the kiln at 60,000 barrels a year, the cost of repairs to the firebrick lining works out at 2.3 pfennig (0.28 penny) per barrel.

It would be seen from these passages that even with the improvements effected, and in spite of the use of selected and expensive firebrick, the corrosion was considerable. The difficulties here described had been wholly overcome in the Hurry-Seaman process, which, using a cheaper form of firebrick, was nevertheless capable of protecting it so completely that the original firebrick lining was intact after two years' use.

Mr. Spackman's communication was interesting as giving a history of the early struggles of American manufacturers to devise a workable rotary process. He was, however, misinformed concerning the lining question, which, in the authors' opinion, was one of the chief determining factors in the successful operation of rotary kilns. The firebricks he advocated, containing a high percentage of alumina,* only served slightly to delay, and not to prevent, the destruction of the lining. The common firebricks, of which they had quoted an analysis, so far from giving trouble served perfectly when properly protected by clinker; the merits and defects of magnesia bricks had been dealt with by Mr. H. le Chatelier and in the paper. The regeneration of the heat of the clinker, though desirable, was not essential to the economy of the process, because the clinker contained only a trifling proportion of the total heat necessary for burning (about 1 to 2%). Many elaborate efforts had been made to pick up this heat by inventors ignorant of thermo-chemistry. The process of systematically moistening the clinker had already been sufficiently dealt with. It was a useful stage of manufacture and certainly not a makeshift. The authors were well acquainted with the practice in other American works, but had selected the Atlas Co.'s works as most completely illustrating modern and rational methods. That they were warranted in this belief was sufficiently shown by the fact that whereas Mr. Spackman put the cost of manufacture in rotary kilns at 16s. per ton of 2,240 lbs., the actual cost at the Atlas works was not more than 12s. 6d. per ton. The high consumption of fuel in burning slurry (40 to 45%) alluded to by Mr. Spackman probably arose from the fact that the kilns with which he had experimented were unduly short. With a kiln of ample length, as shown in the paper, there was no difficulty in reducing the consumption to 30%, the same proportion as was needed for dry raw materials according to present methods. This figure was not merely deducible from the calculations which they had made, but had been reached in practice.

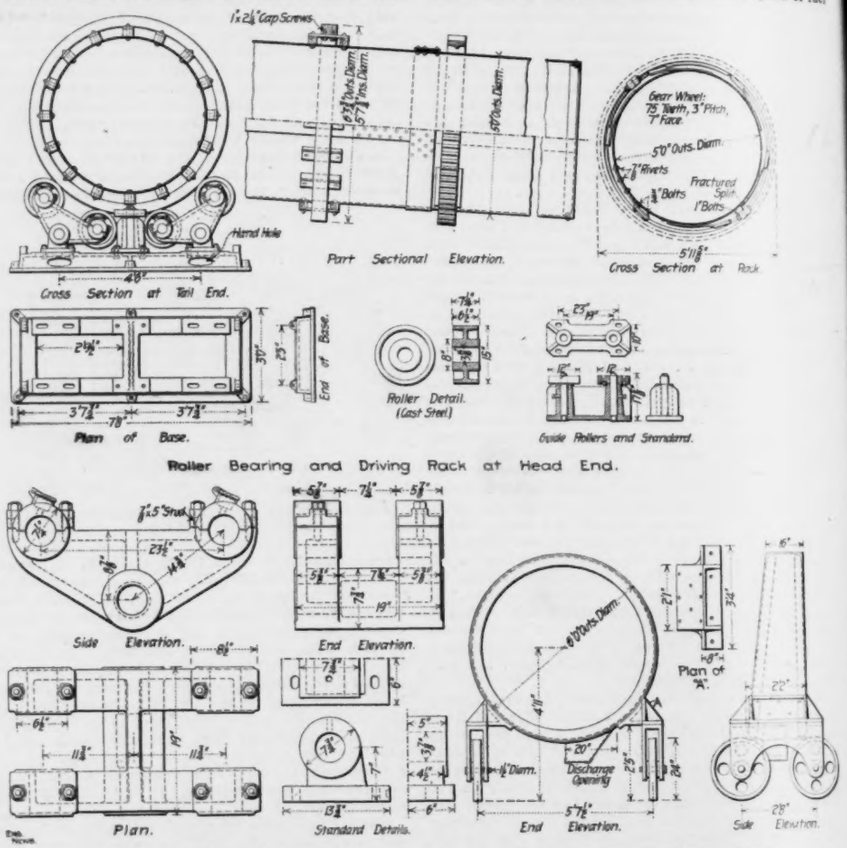


FIG. 9. ENLARGED DETAILS OF 60-FT. ROTARY CEMENT KILN.

(In connection with the preceding discussion of the rotary kiln process for burning Portland cement, we think it may be of interest to many of our readers to study the detail designs for a modern large size rotary kiln, such as is at present used for burning dry materials in the United States. The kiln selected is one recently built by the Vulcan Iron Works of Wilkesbarre, Pa. Fig. 7 shows a diagram plan and elevation of the kiln, and Figs. 8 and 9, show enlarged details of the various parts of the mechanism.—Ed. Eng. News.)

*40% is probably an error; no ordinary aluminous firebrick contains so large a proportion.